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TRAINING SYSTEMS ANALYSIS & DESIGN

AIR CUSHION VEHICLE
OPERATOR TRAINING SYSTEM
(ACVOTS)
SIMULATOR REQUIREMENTS ANALYSIS
VOLUME II OF II

JUNE 1982

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CODE 25
NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

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Prepared By

Allen Corporation of America
401 Wythe Street
Alexandria, Virginia 22314

for

Carol Denton
Naval Training Ecuipment Center
Orlando, Florida 32813

AIR CUSHION VEHICLE OPERATOR TRAINING SYSTEM (ACVOTS) SIMULATOR REQUIREMENTS ANALYSIS VOLUME II OF II

JUNE 1982

J. R. McConville
Head, Surface
Analysis and Design Branch

T. W. McNaney
Head, Training Systems
Analysis and Design Branch

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PREFACE

Volume II of the Air Cushion Vehicle Operator Training System (ACVOTS) Simulator Requirements Analysis contains Appendices A - E. Volume I contains the methodology and results of the analysis.

APPENDIX A

ACVOTS OPERATOR
TRAINING DEVICE OBJECTIVES

MISSION PHASE	1.0	MISSION PLANNING
MISSION PHASE	2.0	MISSION BRIEF
MISSION PHASE	3.0	PRELAUNCH

3.1 Perform Pre-Mission Inspection Checklist Procedures (control cabin only)

CONDITIONS: Given an LCAC craft/simulator control cabin equipped with adjustable seats, safety belts, loose gear, protective gear, (TBD night vision equipment) fire bottles and main circuit breaker panel, craft walk-around checklist complete, using charts, mission plan and pre-mission inspection checklist,

PERFORMANCE: perform pre-mission inspection checklist procedures (control cabin only)

STANDARDS: with 100% accuracy and completion on each deck within three minutes.

3.1.52 Perform Control Cabin Inspection

CONDITIONS: Given an LCAC craft/simulator control cabin equipped with fire bottles, loose gear and circuit breaker panel walk-around inspection complete, using pre-mission inspection checklist,

PERFORMANCE: perform control cabin inspection

STANDARDS: with 100% accuracy and completion within two minutes.

3.1.53 Direct Operating Crew Station Manning

CONDITIONS: Given an LCAC craft/simulator control station equipped with adjustable seats, safety belts and protective gear, control cabin lower deck inspection complete using mission plan, charts, and a pre-mission checklist

PERFORMANCE: direct operating crew station manning to include control cabin and deck readiness

STANDARDS: with 100% accuracy and completion within one minute.

3.2 Start Craft

CONDITIONS: Given an LCAC craft/simulator control station, power-off checklist, APU start checklist, pre-start checklist, main engine(s) start checklist and engine log, with pre-mission checklist complete and personnel clear to start,

PERFORMANCE: start craft

STANDARDS: with 100% accuracy, all systems parameters within safe operating limits, completion within 20 minutes.

3.2.1 Perform Power-Off Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, pre-mission inspection checklist procedures complete, and power-off checklist,

PERFORMANCE: perform power-off checklist procedures

STANDARDS: with 100% accuracy and completion within two minutes.

3.2.2 Perform APU Start Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, APU start checklist and engine log, with power-off checklist prcedures complete and personnel clear to start,

PERFORMANCE: perform APU start checklist procedures

STANDARDS: with 100% accuracy, and completion within one minute.

3.2.3 Perform Pre-Start Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station and pre-start checklist, with APU checklist procedures complete and personnel clear of ramp,

PERFORMANCE: perform pre-start checklist procedures

STANDARDS: with 100% accuracy and completion within one minute.

3.2.4 Perform Main Engine(s) Start Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, main engine(s) start checklist and engine log, with pre-start checklist complete and all stations clear to start,

PERFORMANCE: perform main engine(s) start checklist procedures

STANDARDS: with 100% accuracy, and completion within one minute per engine.

3.3 Perform Pre-Underway Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station and pre-underway checklist, with craft start checklists complete and visual recognition of or communication with deck safety man

PERFORMANCE: perform pre-underway checklist procedures

STANDARDS: with 100% accuracy and completion within 1-1/2 minutes

3.4 Perform Lift-Off and Hover Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station with visual recognition of external structures, physical perception of vibration and yaw, up to 25 knot headwinds, clearance obtained, and lift-off and hover checklist,

PERFORMANCE: perform lift-off and hover checklist procedures

STANDARDS: with 100% accuracy and completion within 20 seconds, limiting craft drift to $\pm$ 2° yaw per second from off-cushion orientation.

MISSION PHASE 4.0 DEPART

4.1 Transit from Land to Water

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded on-cushion, with navigation charts, visual recognition of ramp marshall, land surface, water surface, wave height, wind direction, distance and obstacles and physical perception of roll, pitch, yaw, surge, sway and heave for surf transit, under varying visibility, sea and wind conditions,

PERFORMANCE: transit from land to water

STANDARDS: copying clearance from ramp marshall within 5 seconds and reacting to ramp marshall's signals with 100% accuracy, maneuvering craft to outbound heading 5-45° to port of surf line or $\pm$ 45° of shoreline normal for smooth water departure within 30 seconds after clearance obtained, verifying all systems within safe operating parameters, reaching water above hump speed (16-18 knots) and maintaining speed less than 30 knots for smooth water transit with heading $\pm$ 5°, and speed less than 20 knots for beach to surf transit, bow up attitude (pitch $\geq$ + .8), timing entrance to miss cresting waves in surf transit, within two minute total time, avoiding obstacles and hard surf impacts.

4.1.1 Obtain Clearance As Required

CONDITIONS: Given an LCAC craft/simulator control station craft loaded, on-cushion, with visual recognition of or communication with ramp marshall, and varying visibility and wind conditions,

PERFORMANCE: obtain clearance as required

STANDARDS: copying clearance with 100% accuracy within 5 seconds of communication with ramp marshall.

4.1.2 Maneuver Craft to Outbound Heading

CONDITIONS: Given an LCAC craft/simulator control station craft loaded and on cushion, clearance obtained, with visual recognition of ramp marshall, wind direction, other craft or obstacles/structures, and land surface under varying visibility and wind conditions,

PERFORMANCE: maneuver craft to outbound heading

STANDARDS: within 30 seconds of clearance, maintaining heading 5-45° to port of surf line or $\pm$ 45° of smooth water shoreline normal, verifying all systems within safe operating parameters, and reacting to ramp marshall's signals with 100% accuracy, completion within 1 minute.

4.1.3 Perform Land/Water Transition

CONDITIONS: Given an LCAC craft/simulator control station craft loaded, on cushion, on outbound heading, with navigation charts, visual recognition of beach, distance, land surface, water surface, wave height, wind direction and obstacles, and physical perception of roll, pitch, yaw, surge, sway and heave for surf transit and wind conditions,

PERFORMANCE: perform land/water transition

STANDARDS: reaching water above hump speed (16-18) knots with bow up attitude (pitch $\geq$ + .8) and maintaining speed less than 30 knots for smooth water transit, speed less than 20 knots and bow up attitude (pitch $\geq$ + .8) maintaining heading $\pm$ 5° within envelope $\pm$ 45° of shoreline normal for beach to surf transit, for beach/ramp to smooth water transit and 5-45° to port of surf line for beach to surf transit, timing entrance to miss cresting waves in surf transit, within 1-1/2 minutes, avoiding obstacles and hard surf impacts.

4.1.3.1 Perform Ramp or Slipway to Smooth Water Transition

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, on cushion, on outbound heading, navigation charts, with visual recognition of water surface, ramp surface, obstacles and distance, wind direction, under varying visibility and wind conditions in sea state less than 2,

PERFORMANCE: perform ramp or slipway to smooth water transition

STANDARDS: reaching water above hump speed (16-18) knots with bow up attitude (pitch $\geq$ + .8), speed not exceeding 30 knots, maintaining heading $\pm$ 5 degrees, within envelope of $\pm$ 45° of shoreline normal, within one minute, and avoiding obstacles.

4.1.3.2 Perform Beach to Smooth Water Transition

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, on cushion, on outbound heading, with visual recognition of beach, water surface, obstacles, wind direction and distance, and navigation charts, under varying visibility and wind conditions in sea state less than 2,

PERFORMANCE: perform beach to smooth water transition

STANDARDS: reaching water above hump speed (16-18 knots) with bow up attitude (pitch $\geq$ + .8), maintaining heading $\pm$ 5°, within envelope of $\pm$ 45° of shoreline normal, within one minute, and avoiding obstacles.

4.1.3.3 Perform Beach to Surf Transition

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, on cushion, on outbound heading, visual recognition of beach, distance, water surface, wave height, wind direction and obstacles, and physical perception of roll, pitch, yaw, surge, sway and heave, under varying visibility and wind conditions in sea states 2-5,

PERFORMANCE: perform beach to surf transition

STANDARDS: reaching water with bow up attitude (pitch $\geq$ + .8) and maintaining speed less than 20 knots, timing surf entrance to miss cresting waves, maintaining heading $\pm$ 10° 5-45° to port of surf line, within one minute, avoiding obstacles and hard surf impacts.

4.2 Exit Wet/Dry Well (self-propelled)

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, pre-underway checklist procedures complete, clearance obtained, with minimum 4 ft. water level if wet well, and visual recognition of well deck interior, line handler, water surface, wave height, and wind direction, and physical perception of pitch and yaw under varying visibility, sea, and wind conditions,

PERFORMANCE: exit wet/dry well (self-propelled)

STANDARDS: at speed in accordance with mother ship not to exceed 2 knots difference from ship speed, within 2 minutes, with N_1 to MAX PWR, N_2 to MAX for dry well egress, and N_2 to MIN for wet well egress, avoiding impact with mothership sidewalls.

4.2.1 Perform Mothership Wet Well Egress (self-propelled)

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, pre-underway checklist procedures complete, clearance obtained, minimum 4 ft. water level in well, with visual recognition of well deck interior, line handlers, water surface, wave height, and wind direction, and physical perception of pitch and yaw (once 1/2 clear), under varying visibility, sea, and wind conditions,

PERFORMANCE: perform mothership wet well egress (self-propelled)

STANDARDS: at speed in accordance with mothership, not to exceed 2 knots difference from ship speed, with N_2 at MIN and N_1 at MAX PWR, within 2 minutes, avoiding impact with mothership side walls.

4.2.2 Perform Mothership Dry Well Egress (self-propelled)

CONDITIONS: Given an LCAC craft/simulator control station craft loaded, pre-underway checklist procedures complete, clearance obtained, with visual recognition of dry well deck interior, line handlers, water surface, wave height, and wind direciton and physical perception of pitch and yaw (once half cleared), under varying visibility, sea and wind conditions,

PERFORMANCE: perform mothership dry well egress (self-propelled)

STANDARDS: at speed in accordance with mothership, not to exceed 2 knots difference from ship speed, with N_2 and N_1 to MAX PWR, within 2 minutes, avoiding impact with mothership sidewalls.

4.3 Perform Station Keeping

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, on cushion, with visual recognition of support ship/other craft, water surface, wind direction and distance, under varying visibility, sea and wind conditions,

PERFORMANCE: perform station keeping

STANDARDS: setting controls and maintaining craft position within 2 minutes, maintaining heading on track $\pm$ 10°, and holding position of 500 meters port or starboard of exit centerline of 1000 meters aft of mothership in formation station keeping, for a time period which will be dependent on (assault) wave operations.

4.3.1 Perform Single Station Keeping

CONDITIONS: Given an LCAC craft/simulator control station craft loaded, on-cushion, with visual recognition of support ship, water surface, wind direction, and distance, under varying visibility, sea and wind conditions,

PERFORMANCE: perform single station keeping (set up)

STANDARDS: setting controls to maintain craft position within 2 minutes, maintaining heading on track $\pm$ 10° for a time period which will be dependent on (assault) wave operations.

4.3.2 Perform Formation Station Keeping

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, on-cushion, with visual recognition of support ship/other craft, water surface, wind direction, and distance, under varying visibility, sea, and wind conditions,

PERFORMANCE: perform formation station keeping (set-up)

STANDARDS: setting controls and maintaining craft position within 2 minutes, maintaining heading on track $\pm$ 10° and position of 500 meters port or starboard of exit centerline or 1000 meters aft of mothership for a time period which will be dependent on (assault) wave operations.

4.4 Disengage From Ship

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, engines running, on-cushion if ship underway, boating mode if ship anchored, with visual recognition of ship, water surface, line handler, and wind direction, under varying visibility, sea, and wind conditions,

PERFORMANCE: disengage from ship

STANDARDS: at 10 knots, clearing ship within one minute after verifying release of mooring/aft lines, avoiding tension on lines, ship bow wave and running wake if underway.

MISSION PHASE 5.0 TRANSIT WATER

5.1 Perform Transition Over Hump

CONDITIONS: Given an LCAC craft/simulator control station, craft on-cushion, loaded, CG identified, navigation charts, visual recognition of water surface and traffic, physical perception of yaw, pitch and heave under varying visibility, sea, and wind conditions,

PERFORMANCE: perform transition over hump

STANDARDS: not exceeding 70 knots and on track $\pm$ 10°, reacting to sluggish transition within 10 seconds verifying new heading to locate non-critical water depth to achieve above-hump speed.

5.2 Change Course

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, on track, loaded, with CG identified, navigation charts, visual recognition of water surface, wind direction, traffic, horizon/shoreline, physical perception of roll, pitch and yaw, and aural perception of propeller pitch noise change, under varying visibility, sea and wind conditions,

PERFORMANCE: change course

STANDARDS: avoiding plow-in, pirouette or partial cushion operation, reducing propeller pitch to maintain speed $\pm$ 5 knots, holding upwind turn sideslip below 45° and crosswind and downwind turns sideslip to acceptable limits for given craft speed:

10 knots - 90°
20 knots - 80°
27 knots - 70°
35 knots - 60°
50 knots - 45°
70 knots - 20°

holding sidslip to less than 45° regardless of craft speed for upwind turns and attaining new heading $\pm$ 2° which will result in achieving desired track to next action point.

5.2.1 Change Course Upwind

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, loaded, with CG identified, navigation charts, visual recognition of water surface, wind direction, distance, traffic, horizon/shoreline, physical perception of roll, pitch and yaw, aural perception of propeller pitch noise change, under varying visibility, sea and wind conditions,

PERFORMANCE: change course upwind

STANDARDS: avoiding plow-in, pirouette or partial-cushion operation, reducing propeller pitch to maintain speed ± 5 knots, holding sideslip below 45° regardless of craft speed and attaining new heading ± 2° which will result in achieving desired track to next action point.

5.2.2 Change Course Downwind

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, loaded, CG identified, navigation charts, visual recognition of water surface, wind direction, traffic, horizon/ shoreline, physical perception of roll, pitch and yaw, and aural perception of prop pitch noise change, under varying visibility, sea and wind conditions,

PERFORMANCE: change course downwind

STANDARDS: avoiding plow-in, pirouette and partial cushion operation, reducing propeller pitch to maintain speed ± 5 knots, holding sideslip to acceptable limits for given craft speed:

10 knots - 90°
20 knots - 80°
27 knots - 70°
35 knots - 60°
50 knots - 45°
70 knots - 20°

and attaining new heading ± 2° which will result in achieving desired track to next action point.

5.2.3 Change Course Crosswind

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, loaded, CG identified, navigation charts, visual recognition of water surface, wind direction, traffic, horizon/ shoreline, physical perception of roll, pitch and yaw, and aural perception of propeller pitch noise change, under varying visibility, sea and wind conditions,

PERFORMANCE: change course crosswind

STANDARDS: avoiding plow-in, pirouette or partial cushion operation, reducing propeller pitch to maintain speed ± 5 knots, holding sideslip to acceptable limits for given craft speed:

10 knots - 90°
20 knots - 80°
27 knots - 70°
35 knots - 60°
50 knots - 45°
70 knots - 20°

and attaining new heading ± 2° which will result in achieving desired track to next action point.

5.3 Hold Craft On Track

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, above hump speed, loaded, CG identified, navigation charts, visual recognition of water surface, wind direction, traffic and horizon/shoreline, physical perception of roll, pitch and yaw, under varying visibility, sea and wind conditions,

PERFORMANCE: hold craft on track

STANDARDS: avoiding plow-in, or partial cushion operation and holding craft ± 5° in sea states up to 2 and ± 10° in sea states 2-5, speed TBD based on sea state.

5.4 Maintain Position in Formation Transit

CONDITIONS: Given an LCAC craft/simulator control station, craft underway above hump speed, loaded, with CG identified, navigation charts, visual recognition of water surface, wind direction, other craft and horizon/shoreline, under varying visibility, sea, and wind conditions,

PERFORMANCE: maintain position in formation transit

STANDARDS: maintaining 250 meters fore/aft/side from other craft, TBD variation in relative position with other craft based on type of formation such as trail, echelon or staircase and craft speeds, $\pm$ 5° of track in seas up to 2 and $\pm$ 10° of track in sea states 2-5.

5.5 Perform Mission Dependent Tasks -- TBD

5.6 Perform Underway Main Engine Water Wash

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition, aural perception of engine noise and rough engine performance as indicated by N_1 fluctuations/poor power,

PERFORMANCE: perform underway main engine water wash

STANDARDS: verifying correct connection of water wash kit, application of N_1 MAX PWR during water wash, and main engine water wash procedure sequence followed with 100% accuracy in less than 15 minutes.

5.7 Perform Normal Stopping Over Water

CONDITIONS: Given an LCAC craft/simulator control station craft underway, loaded, identified CG, visual recognition of water surface and wind direction, physical perception of pitch and yaw, under varying visibility, sea and wind conditions,

PERFORMANCE: perform normal stopping over water

STANDARDS: allowing at least 250 ft./10 knots of speed for stopping distance, maintaining craft on track $\pm$ 10° and maintaining bow-up attitude (pitch $\geq$ + .8) to avoid dragging stern.

5.8 Come Off-Cushion Over Water

CONDITIONS: Given an LCAC craft/simulator control station, loaded craft, craft stopped, visual recognition of wind direction and water surface, physical perception of yaw and pitch, navigation charts, and varying visibility, sea, and wind conditions,

PERFORMANCE: come off-cushion over water

STANDARDS: turning into wind/seas (whichever is predominant) applying proportional control inputs to maintain heading $\pm$ 5°, verifying reduction of N_2/N_1 as required to set craft down without hard water impact within one minute.

5.9 Operate In Boating Mode

CONDITIONS: Given an LCAC craft/simulator control station, loaded craft, off-cushion, navigation charts and recognition of water surface, and wind direction, perception of roll, pitch, yaw, sway, surge and heave, under varying visibility (predominantly fog) and wind conditions in maximum 12 foot seas,

PERFORMANCE: operate in boating mode

STANDARDS: making headway at 5 knots (maximum speed of 8 knots), on track $\pm$ 10° of heading while avoiding overtaking stern waves.

5.10 Come On-Cushion Over Water

CONDITIONS: Given an LCAC craft/simulator control station, loaded craft in stationary hullborne position, navigation charts, visual recognition of water surface and wind direction, physical perception of vibration, yaw and heave, and aural perception of engine noise change, under varying visibility, sea and wind conditions,

PERFORMANCE: come on-cushion over water

STANDARDS: verifying N_2 held at 85% until craft trim stabilizes, holding yaw to $\pm$5° and verifying seal bags drained before proceeding within 2 minutes.

MISSION PHASE 6.0 TRANSIT BEACH

6.1 Perform Transit Water to Land

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, loaded, with navigation charts, visual representation of shoreline, wind direction, water surface, and physical perception of roll, pitch, yaw, surge, sway and heave, under varying visibility, sea and wind conditions

PERFORMANCE: perform transit from water to land

STANDARDS: at speed less than 30 knots, on track $\pm$ 5° and heading normal to beach for smooth water approach, and match craft speed to wave speed not exceeding 20 knots, on track $\pm$10° and heading normal to wave direction/beach for surf approach, avoiding obstacles and plow-in at beach, and, if surf transit, avoiding overtaking stern waves.

6.1.1 Perform Smooth Water Approach

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, approaching land with clear path, loaded, with navigation charts, visual recognition of land surface, obstacles, water surface and wind direction and physical perception of pitch and surge, under varying visibility and wind conditions in sea states less than 2,

PERFORMANCE: perform smooth water approach

STANDARDS: not exceeding 30 knots, on track $\pm$ 5° heading normal to beach, avoiding obstacles and plow-in at beach.

6.1.2 Perform Surf Approach

CONDITIONS: Given an LCAC craft/simulator control station craft underway, approaching surf zone with clear path, loaded, with navigation charts, visual recognition of land surface, obstacles, wind direction, water surface, and physical perception of roll, pitch, yaw, surge, sway and heave under varying visibility and wind conditions in sea states 2-5,

PERFORMANCE: perform surf approach

STANDARDS: matching craft speed to wave speed, not to exceed 20 knots, maintaining heading normal to wave direction, avoiding obstacles and plow-in at beach, and avoid overtaking stern waves.

6.2 Fly Up a Slope

CONDITIONS: Given an LCAC craft/simulator control station, navigation charts, craft loaded, identified CG, transit to beach complete, visual recognition of sloping land surface, physical perception of pitch and yaw, and aural perception of engine and propeller pitch noise change, under varying visibility and wind conditions,

PERFORMANCE: fly up a slope

STANDARDS: not exceeding 30 knots, with maximum heading deviation of ± 20° normal to slope, applying propeller pitch as needed to counter wind/slope-affected deceleration, while avoiding obstacles beyond craft limitations.

6.3 Fly Across a Slope

CONDITIONS: Given an LCAC craft/simulator control station, navigation charts, craft loaded, identified CG, with visual recognition of wind direction, sloping land surface and obstacles, physical perception of pitch and yaw and aural perception of propeller pitch noise change, under varying visibility and wind conditions,

PERFORMANCE: fly across a slope

STANDARDS: not exceeding TBD knots, and countering excessive yaw within ± TBD degrees/sec without more than TBD compensating control inputs.

6.4 Hold Craft On Track In Yaw Moment

CONDITIONS: Given an LCAC craft/simulator control station, navigation charts, craft loaded, identified CG, with visual recognition of distant terrain features, (small dunes), and wind direction, physical perception of roll, pitch, yaw, surge, sway and heave, under varying visibility and wind conditions,

PERFORMANCE: hold craft on track in yaw moment

STANDARDS: maintaining course track within 10° of heading, adjusting speed to correlate with anticipated craft behavior not to exceed 35 knots in 25 knot headwind to 50 knots in no wind, with continuous verification (call-out) of terrain features.

6.5 Cross Obstacles

CONDITIONS: Given an LCAC craft/simulator control station, navigation charts and/or intelligence data, craft loaded, identifed CG, underway over land, with visual recognition of distance, land surface and obstacles, physical perception of roll, pitch and yaw, under varying visibility and wind conditions,

PERFORMANCE: cross obstacles

STANDARDS: with N_2 over 90%, continuous verification (call-out) of terrain features and speed reduced to recommended operating speed for given obstacle:

OBSTACLE TYPE	MAXIMUM DIMENSION OF OBSTACLE	RECOMMENDED APPROACH SPEED (KNOTS)
Spikes	2.5 ft.	2 to 10
Vertical Step-up	4.0 ft.	2 to 10
Earth Bank	8.0 ft.	5 to 10
Grass and Reeds	any	5 to 40
Ditch	Less than 5 ft. deep, any width	0 to 20
Step-down	10.0 ft.	10 to 30
Trees	4-inch diameter, 18 feet tall	5 to 30
Wall	5.0 ft.	2 to 15
Ditch	Greater than 5 ft. deep, less than 15 ft.wide	10 to 30
Rocks and Rubble	4.0 ft.	2 to 10
Slope	Up to 30 degrees	25 to 30
Slope	7.2 degrees	5 to 10

6.6 Perform Normal Stopping Overland

CONDITIONS: Given an LCAC craft/simulator control station, craft underway and loaded, identified CG, visual recognition of land surface and/or obstacles and wind direction, and physical perception of pitch and yaw under varying visibility and wind conditions,

PERFORMANCE: perform normal stopping over land

STANDARDS: allowing at least 300 ft. per 10 knots of speed for stopping distance, maintaining craft on track $\pm$ 10 degrees, and maintaining bow-up attitude (pitch $\geq$ + .8) to avoid dragging stern.

6.7 Come Off-Cushion

CONDITIONS: Given LCAC craft/simulator control station craft loaded and stopped, with visual recognition of land surface (sloped or level), wind direction and physical perception of heave or surge and pitch and yaw, under varying visibility and wind conditions,

PERFORMANCE: come off-cushion

STANDARDS: maintaining smooth rate of descent and position on track, $\pm$ 5 degrees, verifying reduction of N_2/N_1, as required to set craft down without hard surface impact within 1 minute, maintaining positive propeller pitch to compensate for thrust loss on sloped surface and avoiding slide off slope.

6.7.1 Come Off-Cushion Level

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, and stopped, with visual recognition of land surface and wind direction, and physical perception of heave and yaw, under varying visibility and wind conditions,

PERFORMANCE: come off-cushion level

STANDARDS: maintain smooth rate of descent and position on track $\pm$ 5°, verifying reduction of N_2/N_1, as required to set craft down without hard surface impact within 1 minute.

6.7.2 Come Off-Cushion On Slope

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, and stopped on slope, with visual recognition of land surface, wind direction, and physical perception of pitch, yaw and surge, under varying visibility and wind conditions,

PERFORMANCE: come off-cushion on slope

STANDARDS: maintain smooth rate of descent and position on track ± 5 degrees, verifying reduction of N_2/N_1, as required to set craft down without hard surface impact within 1 minute, maintaining positive propeller pitch to compensate for thrust loss, avoiding slide off slope.

MISSION PHASE 7.0 AT BEACH

7.1 Supervise Unload

CONDITIONS: Given an LCAC craft/simulator control station, craft loaded, off-cushion on land, with visual recognition of land surface,

PERFORMANCE: supervise unload

STANDARDS: verifying full pad contact with propellers at zero pitch and engines at idle prior to lowering ramps, adjusting fuel for new CG with 100% accuracy, ensuring no delays in unload process.

7.2 Perform Lift-Off and Hover Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, clearance obtained, and lift-off and hover checklist, with visual recognition of beach master if available, land surface and wind direction, physical perception of yaw and heave and aural perception of propeller pitch and engine noise change, under varying visibility and wind conditions,

PERFORMANCE: perform lift-off and hover checklist procedures

STANDARDS: with 100% completion and accuracy of checklist sequence, verifying propeller pitch +10°, N_1 to MAX PWR, and N_2 increased to design cushion (85-92%), maintaining craft heading $\pm$ 5° in one minute, avoiding hovering over land surfaces with loose dirt, sand or leaves.

MISSION PHASE 8.0 DEPART BEACH

8.1 Transit From Land to Water

CONDITIONS: Given an LCAC craft/simulator control station, craft unloaded, on-cushion, with navigation charts, visual recognition of ramp marshall, land surface, water surface, wave height, wind direction, distance and obstacles, physical perception of roll, pitch, yaw, surge, sway, and heave for surf transit, under varying visibility seas and wind conditions,

PERFORMANCE: transit from land to water

STANDARDS: copying clearance from ramp marshall with 5 seconds, and reacting to ramp marshall's signal with 100% accuracy, maneuvering craft to outbound heading 5-45° port to surf line or $\pm$ 45° of shoreline normal for smooth water departure, within 15 seconds after clearance obtained, verifying all systems within safe operating parameters, reaching water above hump speed (16-18 knots) and maintaining speed less than 30 knots for ramp to smooth water transit with heading $\pm$ 5°, less than 20 knots for beach to surf transit with bow-up attitude $\geq$ + .8, timing entrance to miss cresting wave in surf transit, within two minutes total time, avoiding obstacles and hard surf impacts.

8.1.1 Obtain Clearance As Required

CONDITIONS: Given an LCAC craft/simulator control station, craft unloaded, on-cushion, with visual recognition or communication with ramp marshall, and varying visibility and wind conditions,

PERFORMANCE: obtain clearance as required

STANDARDS: copying clearance with 100% accuracy, within 5 seconds of communication with ramp marshall.

8.1.2 Maneuver Craft to Outbound Heading

CONDITIONS: Given an LCAC craft/simulator control station, craft unloaded and on-cushion, clearance obtained, with visual recognition of ramp marshall, wind direction, other craft or obstacles/structures and land surface, under varying visibility and wind conditions,

PERFORMANCE: maneuver craft to outbound heading

STANDARDS: within 30 seconds of clearance, maintaining heading 5-45° port of surf line or $\pm$ 45° of smooth water shoreline normal, and verifying all systems within safe operating parameters, and reacting to ramp marshall's signal with 100% accuracy and completion within one minute.

8.1.3 Perform Land to Water Transition

CONDITIONS: Given an LCAC craft/simulator control station craft unloaded, on-cushion, on outbound heading, with navigation charts, visual representation of beach, distance, land surface, water surface, wave height, wind direction and obstacles, and physical perception of roll, pitch, yaw, surge, sway and heave, under varying visibility, seas, and wind conditions,

PERFORMANCE: perform land to water transition

STANDARDS: reaching water above hump speed (16-18 knots) with bow-up attitude (pitch $\geq$ + .8), and maintaining speed less than 30 knots for smooth water transit, transit speed less than 20 knots for beach to surf transit, and bow-up attitude (pitch $\geq$ + .8), maintaining heading $\pm$ 5° or within envelope $\pm$ 45° of shoreline normal for beach/ramp to smooth water transit and $\pm$ 5-45° to port of surf line for beach to surf transit, timing entrance to miss cresting wave in surf transit, within 1-1/2 minutes, avoiding obstacles and hard surf impacts.

8.1.3.1 Perform Land to Smooth Water Transition

CONDITIONS: Given an LCAC craft/simulator control station craft unloaded, on-cushion, on outbound heading, with navigation charts, visual recognition of beach, water surface, obstacles, wind direction, and distance, under varying visibility and wind conditions in sea states less than 2,

PERFORMANCE: perform land to smooth water transition

STANDARDS: reaching water above hump speed (16-18 knots) with bow-up attitude (pitch $\geq + .8$), speed not exceeding 30 knots, maintaining heading $\pm 5°$, within one minute, and avoiding obstacles.

8.1.3.2 Perform Land to Surf Transition

CONDITIONS: Given an LCAC craft/simulator control station, craft unloaded, on-cushion, on outbound heading, navigation charts, visual representation of beach, distance, water surface, wave height, wind direction and obstacles, and physical perception of roll, yaw, pitch, surge, sway and heave, under varying visibility and wind conditions in sea states 2-5,

PERFORMANCE: perform land to surf transition

STANDARDS: reaching water with bow up attitude (pitch $\geq + .8$) and maintaining speed less than 20 knots, timing surf entrance to miss cresting waves, maintaining heading $\pm 20°$, 5-45° port to surf line, within one minute, avoiding obstacles and hard surf impacts.

MISSION PHASE 9.0 TRANSIT WATER

9.1 Perform Transition Over Hump (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with an identified craft CG, craft on-cushion, navigation charts, visual recognition of water surface and traffic, physical perception of yaw, pitch and heave under varying visibility, sea and wind conditions,

PERFORMANCE: perform transition over hump (unloaded)

STANDARDS: speed not to exceed 70 knots at ± 10° of track, avoiding partial cushion operation and reacting to sluggish transition within 10 seconds verifying heading to locate non-critical water depth to achieve above-hump speed.

9.2 Change Course (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with an identified CG, craft underway on track, navigation charts, visual recognition of water surface, wind direction, horizon/shoreline, and traffic, physical perception of roll, pitch and yaw, aural perception of propeller pitch noise change under varying visibility, sea and wind conditions,

PERFORMANCE: change course (unloaded)

STANDARDS: avoiding plow-in, or pirouette, or partial cushion operation, reducing prop pitch to maintain speed ± 5 knots, and holding upwind turn sideslip below 45° and crosswind and downwind turns sideslip to acceptable limits for given craft speed:

- 10 knots - 90°
- 20 knots - 80°
- 27 knots - 70°
- 35 knots - 60°
- 50 knots - 45°
- 70 knots - 20°

holding sideslip to less than 45° regardless of craft speed for upwind turn, and attaining new heading ± 2° which will result in achieving desired track to next action point.

9.2.1 Change Course Upwind (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with identified CG, craft underway on track, navigation charts, visual recognition of water surface, wind direction, horizon/shoreline distance, and traffic, physical perception of roll, pitch and yaw, and aural perception of propeller pitch noise change under varying visibility, sea and wind conditions,

PERFORMANCE: change course upwind (unloaded)

STANDARDS: avoiding plow-in, pirouette or partial cushion operation, reducing prop pitch to maintain speed ± 5 knots, holding sideslip to less than 45° regardless of craft speed, and attaining new heading of ± 2° which will result in achieving desired track to next action point.

9.2.2 Change Course Downwind (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with identified CG, craft underway on track, navigation charts, visual recognition of water surface, wind direction, horizon/ shoreline, traffic, physical perception of roll, pitch and yaw, and aural perception of propeller pitch noise change under varying visibility, sea and wind conditions,

PERFORMANCE: change course downwind (unloaded)

STANDARDS: avoiding plow-in, pirouette and partial cushion operation, reducing prop pitch to maintain speed ± 5 knots, holding sideslip to acceptable limits for given craft speed:

- 10 knots - 90°
- 20 knots - 80°
- 27 knots - 70°
- 35 knots - 60°
- 50 knots - 45°
- 70 knots - 20°

and attaining new heading ± 2° which will result in achieving desired track to next action point.

9.2.3 Change Course Crosswind (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with identified CG, craft underway on track, navigation charts, visual recognition of water surface, wind direction, horizon/shoreline, traffic, physical perception of roll, pitch and yaw, and aural perception of propeller pitch noise change under varying visibility, sea and wind conditions,

PERFORMANCE: change course crosswind (unloaded)

STANDARDS: avoiding plow-in, pirouette or partial cushion operation, reducing prop pitch to maintain speed ± 5 knots, holding sideslip to acceptable limits for given craft speed:

- 10 knots - 90°
- 20 knots - 80°
- 27 knots - 70°
- 35 knots - 60°
- 50 knots - 45°
- 70 knots - 20°

and attaining new heading ± 2° which will result in achieving desired track to next action point.

9.3 Hold Craft on Track (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with identified CG, craft underway above hump speed, navigation charts, visual recognition of water surface, wind direction, horizon/shoreline, and traffic, physical perception of roll, pitch and yaw, under varying visibility, sea and wind conditions,

PERFORMANCE: hold craft on track (unloaded)

STANDARDS: avoiding plow-in, or partial cushion operation and holding craft on track ± 5° in sea states up to 2 and ± 10° in sea states 2-5, speed TBD based on sea state.

9.4 Maintain Position in Formation Transit (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station with identified CG, craft underway above hump speed, navigation charts, visual recognition of water surface, wind direction, horizon/shoreline, traffic and other craft, under varying visibility, sea and wind conditions,

PERFORMANCE: maintain position in formation transit (unloaded)

STANDARDS: maintaining 250 meters fore/aft/side from other craft, TBD variation in relative position with other craft, based on type of formation such as trail, echelon or staircase and craft speeds, $\pm$ 5° of track in sea states up to 2 and $\pm$ 10° of track in sea states 2-5.

9.5 Perform Mission Dependent Tasks - TBD

9.6 Perform Underway Main Engine Water Wash

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, aural perception of engine noise, and rough engine performance as indicated by N_1 fluctuations/poor power,

PERFORMANCE: perform underway main engine water wash,

STANDARDS: verifying correct connection of water wash kit on each engine, correct application of N_1 (MAX PWR) during wash and performance of main engine water wash procedure sequence with 100% accuracy in less than 15 minutes.

9.7 Perform Normal Stopping Over Water

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, unloaded, identified CG, visual recognition of water surface and wind direction, physical perception of pitch and yaw, under varying visibility, sea and wind conditions,

PERFORMANCE: perform normal stopping over water

STANDARDS: allowing at least 250 ft./10 knots of speed for stopping distance, maintaining craft on track $\pm$ 10° and maintaining bow up attitude (pitch $\geq$ + .8) to avoid dragging stern.

9.8 Come Off-Cushion Over Water (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station, craft stopped, navigation charts, visual recognition of water surface and wind direction, physical perception of yaw and pitch under varying visibility, sea and wind conditions,

PERFORMANCE: come off-cushion over water (unloaded)

STANDARDS: turning into wind/seas (whichever is predominant), applying proportional control inputs to maintain heading $\pm$ 5°, verifying reduction of N_2/N_1, as required, to set craft down without hard water impact within 1 minute.

9.9 Operate in Boating Mode

CONDITIONS: Given an LCAC craft/simulator control station, craft off-cushion, navigation charts and visual recognition of water surface and wind direction, perception of roll, pitch, yaw, sway, surge and heave, under varying visibility (predominantly fog) and wind conditions, in maximum 12 foot seas,

PERFORMANCE: operate in boating mode

STANDARDS: making headway at 5 knots (not greater than 8 knots) on track $\pm$ 10° of heading while avoiding overtaking stern waves.

9.10 Come On-Cushion Over Water (unloaded)

CONDITIONS: Given an LCAC craft/simulator control station, craft in stationary hullborne position, navigation charts, visual recognition of water surface and wind direction, physical perception of vibration, yaw and heave, and aural perception of engine noise change under varying visibility, sea and wind conditions,

PERFORMANCE: come on-cushion over water (unloaded)

STANDARDS: verifying N_2 held to 85% until craft trim stabilizes, holding yaw to $\pm$ 5° and verifying seal bags drained before proceeding, within 2 minutes.

MISSION PHASE 10.0 RECONFIGURE

10.1 Fly Up to Moving Ship

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on-track, identified CG, approaching underway ship, with visual recognition of underway ship, water surface and wind direction, with varying visibility, sea and wind conditions,

PERFORMANCE: fly up to moving ship

STANDARDS: reducing speed to slowly overtake ship underway at 12 knots maximum, approaching ship in the trough between waves, avoiding ship bow wave and running wake, stopping within TBD meters of ship.

10.2 Moor to Ship

CONDITIONS: Given an LCAC craft/simulator control station, craft on-track, approaching ship underway/anchored or pier, CG identified, with visual recognition of ship, line handlers, water surface, wave height, and wind direction, under varying visibility, sea, ship orientation, and wind conditions,

PERFORMANCE: moor to ship

STANDARDS: underway by reducing craft speed to slowly overtake ship not to exceed 12 knots, keeping station 25-30 ft. abeam of over-the-side loading station on ship, approaching ship between waves and avoiding ship bow wave and running wake; or anchored ship/pier by reducing headway to near zero within ± TBD meters of ship/pier approaching with craft bow into the wind or seas, within safe boating parameters and avoiding hard impacts.

10.2.1 Moor to Ship Underway

CONDITIONS: Given an LCAC craft/simulator control station, craft on-track and approaching ship underway, CG identified, with visual recognition of ship, line handlers, water surface, wave height and wind direction, under varying visibility, sea, ship orientation and wind conditions,

PERFORMANCE: moor to ship underway

STANDARDS: reducing craft speed to slowly overtake ship underway not to exceed 12 knots keeping station 25-30 ft. abeam of over-the-side loading station on ship, approaching ship between waves, avoiding ship bow wave and running wake.

10.2.2 Moor to Ship at Anchor (or Pier)

CONDITIONS: Given an LCAC craft/simulator control station craft, on track, approaching ship at anchor or pier, CG identified, with visual recognition of ship/pier, line handlers, water surface, wave height and wind direction, under varying visibility, sea, ship orientation, and wind conditions,

PERFORMANCE: moor to ship at anchor (or pier)

STANDARDS: reducing headway to near zero, within ± TBD meters of ship/pier, approaching with craft bow into the wind or seas, within safe boating parameters, and avoiding hard impacts.

10.3 Refuel/Reload Craft

CONDITIONS: Given an LCAC craft/simulator control station approaching underway ship for refueling, with underway refueling preparation checklist, underway refueling checklist, or approaching ship at anchor for reloading with reload preparations checklist, and visual recognition of wind direction, water surface, wave height, ship, loading crane and boom or fuel boom under varying visibility, sea and wind conditions,

PERFORMANCE: refuel/reload craft

STANDARDS: with 100% completion and accuracy of checklists sequence, and adjusting fuel trim for new CG, with operating gross weight not exceeding 365,000 pounds reload, maintaining same speed as ship, not to exceed 12 knots, holding position 25-30 feet abeam of ship for reload and regulating fuel pump to maximum 500 GPM at 60 lb/in^2 for refuel.

10.3.1 Perform Underway Refueling

CONDITIONS: Given an LCAC craft/simulator control station, fuel low, craft approaching ship underway, with underway refueling preparations checklist, underway refueling checklist and visual recognition of ship, fuel boom, wind direction and water surface, under varying visibility, sea, and wind conditions,

PERFORMANCE: perform underway refueling

STANDARDS: maintaining same speed as ship, not to exceed 12 knots, holding position at 25-30 feet abeam of ship, regulating fuel pump to maximum 500 GPM at 60 lb/in^2 and adjusting fuel trim for new CG calculation, with 100% completion and accuracy of checklist sequence.

10.3.2 Reload Craft (at anchor)

CONDITIONS: Given an LCAC craft/simulator control station, craft moored to ship at anchor and reload preparations checklist, with visual recognition of ship, loading crane on a boom, water surface, wave height, and wind direction, under varying visibility, sea and wind conditions,

PERFORMANCE: reload craft (at anchor)

STANDARDS: with 100% accuracy of checklist sequence, with load not to exceed operating gross weight of 365,000 lbs., adjusting fuel trim for new CG calculation and maintaining position of 25-30 feet abeam of ship.

10.4 Enter Well Deck

CONDITIONS: Given an LCAC craft/simulator control station, craft partial to off-cushion for wet well entries, on-cushion for dry well entry, craft approching ship underway with visual recognition of support ship, water surface, wave height, line handlers and lines, and wind direction, physical perception of pitch, yaw and sway, under varying visibility, sea, and wind conditions,

PERFORMANCE: enter well deck

STANDARDS: verifying deck and personnel clear, verifying support ship underway 1-3 knots for wet well entry and 5-8 knots for dry well entry adjusting control inputs at or about 10 ft. from well deck, to maintain track $\pm$ 2° within two minutes of 10 ft. threshold.

10.5 Perform Transit from Water to Land

CONDITIONS: Given an LCAC craft/simulator control station craft unloaded, underway, approaching land with clear path, navigation charts, and visual representation of land surface, obstacles, water surface, wave height, and wind direction and physical perception of roll, pitch, yaw, surge, sway and heave under varying visibility, sea, and wind conditions,

PERFORMANCE: perform transit from water to land

STANDARDS: at speed less than 30 knots, on track $\pm$ 5°, and heading normal to beach for smooth water approach, and match craft speed to wave speed not exceeding 20 knots, on track $\pm$10°, and heading normal to wave direction/beach for surf approach, avoiding obstacles and plow-in at beach, and, if surf, avoid overtaking stern waves.

10.5.1 Perform Smooth Water Approach

CONDITIONS: Given an LCAC craft/simulator control station, underway approaching land, with clear path, unloaded, and with navigation charts and visual recognition of land surface, obstacles, water surface and wind direction, and physical perception of pitch and surge, under varying visibility and wind conditions in sea states less than 2,

PERFORMANCE: perform smooth water approach

STANDARDS: not exceeding 30 knots, on track $\pm$ 5° heading normal to beach, avoiding obstacles and plow-in at beach.

10.5.2 Perform Surf Approach

CONDITIONS: Given an LCAC craft/simulator cntrol station, underway, approaching surf zone, with clear path, unloaded, with navigation charts and visual recognition of land surface, obstacles, water surface, wave height, and wind direction, and physical perception of roll, pitch, yaw, surge, heave and sway under varying visibility and wind conditions in sea states 2-5,

PERFORMANCE: perform surf approach

STANDARDS. with craft speed matched to wave speed, not to exceed 20 knots, maintaining heading normal to wave direction/beach, avoiding obstacles, plow-in at beach and overtaking stern waves.

MISSION PHASE 11.0 POST MISSION

11.1 Bring Craft Off-Cushion

CONDITIONS: Given an LCAC craft/simulator control station craft stopped, with visual recognition of land surface, wind direction, and obstacles, and physical perception of yaw and reduced vibration, under varying visibility and wind conditions,

PERFORMANCE: bring craft off-cushion

STANDARDS: maintaining smooth rate of descent and heading $\pm$ 5°, verifying reduction of N_2/N_1, as required to set craft down without hard surface impact within one minute, maintaining positive propeller pitch if surface is sloping, avoiding slide off slope.

11.2 Perform Craft Securing Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft stopped, off-cushion, mission complete, with craft securing checklist, engine log, and visual recognition of external power connection,

PERFORMANCE: perform craft checklist procedures

STANDARDS: with 100% completion and accuracy of checklist procedures in sequence, within 12 minutes, reacting to abnormal noises, purging engine if EGT remains above 450° after N_1 RPM at 0%, and verifying low pressure warning lights illuminated.

11.2.1 Perform Equipment Shutdown Procedures

CONDITIONS: Given an LCAC craft/simulator control station, mission complete, craft stopped, off-cushion, and craft securing checklist,

PERFORMANCE: perform equipment shutdown procedures

STANDARDS: with 100% completion and accuracy of equipment shutdown checklist procedures sequence in less than 5 minutes.

11.2.2 Perform Engine Shutdown Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft securing checklist and engine log, with equipment shutdown procedures complete,

PERFORMANCE: perform engine shutdown procedures

STANDARDS: with 100% completion and accuracy of engine shutdown checklist procedures sequence in less than 5 minutes, reacting for abnormal noises, purging engine if EGT remains above 450°F. after N_1 RPM at 0%, verifying low pressure warning lights illuminated.

11.2.3 Perform APU Shutdown Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft securing checklist, and visual recognition of external power connection, with engine shutdown procedures complete,

PERFORMANCE: perform APU shutdown procedures

STANDARDS: with 100% completion and accuracy of APU shutdown checklist procedures sequence in less than 2 minutes.

11.3 Perform Refueling

CONDITIONS: Given an LCAC craft/simulator control station craft secured, fuel low (refueling checklist), and visual recognition of fuel line and deck safety man,

PERFORMANCE: perform refueling

STANDARDS: with 100% completion and accuracy of checklist procedures sequence, in less than 45 minutes verifying fuel lights illuminated and observing all standard fire and safety precautions.

11.4 Perform Mission Log Completion

CONDITIONS:	Given an LCAC craft/simulator control station, mission complete, craft secured, refueling complete, and mission log,
PERFORMANCE:	perform mission log completion
STANDARDS:	with 100% completion of required mission log information following craft securing/refueling and prior to exiting control station at end of mission.

MISSION PHASE 12.0 MISSION DEBRIEF

MISSION PHASE 13.0 PERFORM EMERGENCY AND ABNORMAL CONDITIONS PROCEDURES

13.1 Perform Emergency Stopping

CONDITIONS: Given an LCAC craft/simulator control station, craft underway and visual contact of water/land surface, and other craft/obstacles (if initiated by collision course), under varying visibility, wind and sea (if over water) conditions, operating at speed $\geq$ 15 knots,

PERFORMANCE: perform emergency stopping

STANDARDS: immediately reacting to collision course alert, unanticipated obstacles or as dictated by the tactical situation, stopping craft in less than thirty seconds, holding sideslip within craft control limitations and verifying craft shutdown if collision is unavoidable.

13.1.1 Perform Emergency Stopping Over Land

CONDITIONS: Given an LCAC craft/simulator control station, craft underway at 15 knots or more, and visual contact of land surface and other craft/obstacles (if initiated by collision course), under varying visibility and wind conditions,

PERFORMANCE: perform emergency stopping over land

STANDARDS: immediately reacting to collision course alert, unanticipated obstacles or as dictated by the tactical situation, stopping craft in less than thirty seconds, holding sideslip within craft control limitations and verifying craft shutdown if collision is unavoidable.

13.1.2 Perform Emergency Stopping Over Water

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, and visual contact of water surface and other craft/obstacles (if initiated by collision course), under varying visibility, wind and sea conditions,

PERFORMANCE: perform emergency stopping over water

STANDARDS: immediately reacting to collision course alert, unanticipated obstacles or as dictated by the tactical situation, stopping craft in less than thirty seconds, holding sidelsip within craft control limitations and verifying craft shutdown if collision is unavoidable.

13.2 Perform Fire Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, and visual and/or aural recognition of smoke, flames or explosion, under varying visibility and wind conditions,

PERFORMANCE: perform fire emergency procedures

STANDARDS: reacting to Master Fire light within 3 seconds, and performing fire emergency procedures sequence with 100% accuracy observing all standard fire and safety precautions.

13.2.1 Perform Engine Fire Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, and visual recognition of smoke, under varying visibility, sea and wind conditions,

PERFORMANCE: perform engine fire emergency procedures

STANDARDS: reacting to master fire light within 3 seconds, and performing engine fire emergency procedures sequence with 100% accuracy observing all standard fire and safety precautions.

13.2.2 Perform APU Fire Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, and visual recognition of smoke, under varying visibility, sea and wind conditions,

PERFORMANCE: perform APU fire emergency procedures

STANDARDS: reacting to Master Fire light within 3 seconds, and performing APU fire emergency procedures sequence with 100% accuracy observing all standard fire and safety precautions.

13.2.3 Perform Craft Fire Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, visual/aural recognition of smoke/alarm, under varying visibility, sea and wind conditions,

PERFORMANCE: perform craft fire emergency procedures

STANDARDS: reacting to Master Fire light and/or smoke, alarm or alert by other crew member within 3 seconds, and performing craft fire emergency procedures sequence with 100% accuracy observing all standard fire and safety precautions.

13.2.4 Perform Deck Cargo/Equipment Fire Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, visual recognition of smoke, flames or explosion, under varying visibility, sea and wind conditions,

PERFORMANCE: perform deck cargo/equipment fire emergency procedures

STANDARDS: reacting to fire indications within 3 seconds by maneuvering craft to position where fire is downwind of crew station and alerting crew, performing deck cargo/equipment fire emergency procedures sequence with 100% accuracy and observing all standard fire and safety precautions.

13.3 Recognize and React to Propulsion Power Loss Emergencies

CONDITIONS: Given an LCAC craft/simulator control station and the following conditions for individual propulsion power loss emergencies:

Single Engine: craft underway on track, aural recognition of engine noise change;

Multiple Engine: craft underway on track, aural recognition of engine noise change and physical perception of roll, pitch and yaw;

Transmission: craft underway on track, aural recognition of propeller pitch and fan noise change and physical perception of vibration, roll, pitch and yaw;

N_2 Govern: craft underway on track, aural recognition of engine noise changes and physical perception of vibration and heave;

Fueling: during refueling, with sight of the fuel boom, lack of presure in nozzle or manifold lights, lack of port or starboard TANK FULL lights and/or fuel/water on deck;

Fuel System (Main Engines): craft underway on track, visual recognition of land/water surface, fuel pressure gauge below normal, fuel low pressure light on, fuel management panel low pressure light on, or master caution light on;

Fuel System (APU): craft underway on track, visual recognition of land/water surface, APU low pressure light on, APU RPM drop or secondary bus equipment dropping off line, under varying visibility, sea and wind conditions,

PERFORMANCE: recognize and react to propulsion power loss emergencies

STANDARDS: Single Engine: reacting to master caution light and/or engine parameter changes within 5 seconds, adjusting control inputs to maintain craft control;

Multiple Engine: reacting to master caution .ight and/or engine parameter changes within 3 seconds, adjusting control inputs to maintain craft control;

Transmission: reacting to lube oil status panel lights, vibration or noise, assessing problem within 15 seconds, adjusting control inputs to maintain craft control;

N_2 Govern: reacting to erratic or no control of N_2, vibration or excessive heave within 5 seconds;

Fueling: stopping fueling within 3 seconds of indication, following all standard fire and safety precautions;

Fuel System (Main Engines): beginning fuel system (main engines) failure emergency procedures sequence within 3 seconds of indication(s), following all standard fire and safety precautions, performing engine shutdown if both primary and secondary low pressure lights are illuminated;

Fuel System (APU): beginning fuel system (APU) failure emergency procedures sequence within 3 seconds of indication(s), following all standard fire and safety precautions;

and following individual propulsion power loss emergency procedures sequence to 100% accuracy.

13.3.1 Perform Single Engine Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, aural recognition of engine noise change under varying visibility, sea and wind conditions,

PERFORMANCE: perform single engine failure emergency procedures

STANDARDS: reacting to master caution light and/or engine parameter changes within 5 seconds, adjusting control inputs to maintain craft control and performing single engine failure emergency procedures with 100% accuracy.

13.3.2 Perform Multiple Engine Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, aural recognition of engine noise change, and physical perception of roll, pitch and yaw, under varying visibility, sea and wind conditions,

PERFORMANCE: perform multiple engine failure emergency procedures

STANDARDS: reacting to Master Caution light and/or engine parameter changes within 3 seconds, adjusting control inputs to maintain craft control and performing multiple engine failure emergency procedures sequence with 100% accuracy.

13.3.3 Perform Transmission Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, aural recognition of propeller pitch and fan speed noise changes and physical perception of vibration, roll, pitch and yaw under varying visibility, sea and wind conditions,

PERFORMANCE: perform transmission failure emergency procedures

STANDARDS: reacting to lube oil status panel lights, vibration or noise, assessing problem within 15 seconds, adjusting control inputs to maintain craft control and performing transmission failure emergency procedure sequence with 100% accuracy.

13.3.4 Perform N_2 Govern Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, aural recognition of engine noise changes, and physical perception of vibration and heave under varying visibility and wind conditions,

PERFORMANCE: perform N_2 govern failure emergency procedures

STANDARDS: reacting to erratic or no control of N_2, vibration or excessive heave within 5 seconds, and following N_2 Govern Failure Emergency Procedures sequence with 100% accuracy.

13.3.5 Perform Fueling Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station during refueling, with sight of the fuel boom, lack of pressure in nozzle or manifold lights, lack of Port or Starboard Tank Full lights, or fuel and/or water on deck,

PERFORMANCE: perform fueling failure emergency procedures

STANDARDS: stopping fueling process within 3 seconds of indication, following fueling failure emergency procedures sequence with 100% accuracy and following all standard fire and safety precautions.

13.3.6 Perform Fuel System Failure (Main Engines) Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station on track, visual recognition of land/water surface, fuel pressure gauge below normal, fuel low pressure light on, fuel management panel low pressure light on, or master caution light on, under varying visibility, sea and wind conditions,

PERFORMANCE: perform fuel system failure (main engines) emergency procedures

STANDARDS: beginning fuel system failure emergency procedure sequence within 3 seconds of indication(s) to 100% accuracy, following all standard fire and safety precautions and performing engine shutdown if both primary and secondary port and starboard low pressure lights are illuminated.

13.3.7 Perform Fuel System Failure (APU) Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway, on track, visual recognition of land/water surface, APU low pressure light on, APU RPM drop or secondary bus equipment dropping off line under varying visibility, sea and wind conditions,

PERFORMANCE: perform fuel system failure (APU) emergency procedures

STANDARDS: beginning fuel system (APU) failure emergency procedure sequence within 3 seconds of indication(s) to 100% accuracy, and following all standard fire and safety precautions.

13.4 Recognize and React to Lift System Failures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, perception of velocity and distance, aural recognition of fan noise changes and physical perception of roll, pitch and yaw*, under varying visibility, sea and wind conditions,

*such as soft roll response, change in steering response, tendency to list or crab, large roll in turns or craft attitude change

PERFORMANCE: recognize and react to Lift System Failures

STANDARDS: reacting to warnings within 5 seconds, performing lift system failure emergency procedure sequence with 100% accuracy: in loss of keel or lateral stability bags, slowing craft to avoid plow-in, in cushion failure, verifying increase of N_2 to MAX PWR for maximum cushion maintenance and in general, adjusting craft control inputs to counter moments greater than TBD degrees per second.

13.4.1 Perform Cushion Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, perception of velocity and distance, aural recognition of fan noise change and physical perception of roll, pitch and yaw from craft attitude change under varying visibility, sea and wind conditions,

PERFORMANCE: perform cushion failure emergency procedures

STANDARDS: reacting to warnings within 5 seconds, performing cushion failure emergency procedures sequence (including emergency stopping and maintenance of available cushion) with 100% accuracy, adjusting craft control inputs to counter moments greater than TBD degrees per second.

13.4.2 Perform Loss of Keel or Lateral Stability Bags Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of water surface (wave height), perception of velocity and distance, physical perception of roll, pitch and yaw, via soft roll response, change in steering response, tendency to list or crab, or large roll angle in turns under varying visibility, sea and wind conditions,

PERFORMANCE: perform loss of keel or lateral stability bags emergency procedures

STANDARDS: beginning craft slowdown within 3 seconds of indication(s), verifying N_2 set to MAX PWR to maintain highest cushion possible and cautiously returning to home base.

13.4.3 Perform Loss of Lift Fan Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, aural recognition of fan noise change and physical perception of roll, pitch and yaw via change in craft attitude or N_2 fluctuations under varying visibility, sea and wind conditions,

PERFORMANCE: perform loss of lift fan emergency procedures

STANDARDS: beginning normal quick stop within 3 seconds of indication(s), closing cushion vanes, verifying N_2 set to MAX PWR to maintain highest cushion possible, adjusting bow thruster vanes for new power setting and following loss of lift fan emergency procedure sequence with 100% accuracy.

13.5 Recognize and React to Degradation of Craft Control

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, aural recognition of APU noise change (APU failure) or propeller pitch noise change (propeller failure), physical perception of roll, yaw and/or sway and maintenance log under varying visibility, sea and wind conditions,

PERFORMANCE: recognize and react to degradation of craft control

STANDARDS: reacting to indication(s) within 3 seconds, adjusting craft control inputs to compensate for degradation and following craft control loss emergency procedures sequence with 100% accuracy following all standard fire and safety precautions.

13.5.2 Perform Propeller Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, maintenance log, visual recognition of land/water surface, aural recognition of propeller pitch noise change and physical perception of roll, yaw and vibration, under varying visibility and wind conditions,

PERFORMANCE: perform propeller failure emergency procedures

STANDARDS: reacting to indication(s) within 3 seconds, adjusting to differential propeller pitch to avoid plow-in, dumping cushion as soon as possible, following propeller pitch failure emergency procedure sequence with 100% accuracy following all standard fire and safety precautions.

13.5.4 Perform Bow Thruster Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, physical perception of yaw and sway (if both feedback potentiometers fail) from loss of control, panel indications such as Master Caution light, annunciator panel (MARCON) flight control light or control system test panel light and maintenance log, under varying visibility, sea and wind conditions,

PERFORMANCE: perform bow thruster failure emergency procedures

STANDARDS: reacting to indication(s) with 5 seconds, performing bow thruster failure emergency procedures sequence with 100% accuracy following standard fire and safety precautions.

13.5.5 Perform APU Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, aural recognition of APU noise change (if starboard side), panel indications such as APU N_1 RMP droo, Master Caution light, annunciator (MARCON) Generator Out light and maintenance log under varying visibility, sea and wind conditions,

PERFORMANCE: Perform APU Failure Emergency Procedures

STANDARDS: reacting to indication(s) within 5 seconds and following APU failure emergency procedure sequence with 100% accuracy following all standard fire and safety precautions.

13.5.6 Perform Generator Failure Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of land/water surface, aural recognition of APU noise change (if starboard side), panel indications such as Master Caution light, annunciator (MARCON) panel Generator Out light flashing or loss of secondary bus and maintenance log, under varying visibility, sea and wind conditions,

PERFORMANCE: perform generator failure emergency procedures

STANDARDS: reacting to indication(s) with 5 seconds and following generator failure emergency procedures sequence with 100% accuracy, following all standard fire and safety precautions.

13.6 Perform Miscellaneous Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station and the following conditions for individual miscellaneous emergency procedures:

Flooding: craft underway on track, visual recognition of water surface and physical perception of roll, pitch, surge, heave or sluggish motion via change in craft attitude or listing;

Man Overboard: craft underway on track or refueling, visual recognition of water surface and man overboard (or position alert from other crewmember);

Collision: craft having just collided with other craft or obstacle, visual recognition of water/land surface and other craft/obstacle and physical perception of impact, roll, pitch, yaw, sway, surge and heave;

Plow-in: craft underway on track, visual recognition of water surface (and shoreline if approaching beach), aural recognition of pitch clicks, physical recognition of fingers telegraphing, pitch, roll, vibration or negative surge and panel indication of pitch less than +.8;

under varying visibility, sea and wind conditions,

PERFORMANCE: perform miscellaneous emergency procedures,

STANDARDS: Flooding: reacting to craft attitude change or indication(s) within 3 seconds, verifying N_2 set to MAX PWR to maintain maximum cushion, turning craft towards beach or shallow water;

Man Overboard: beginning craft slowdown to below hump speed and/or turnabout to victim position within 5 seconds of alert, lowering ramp to pickup only if sea state less than or equal to 2;

Collision: reacting to situation within 3 seconds, verifying N_2 set to MAX PWR to maintain maximum cushion, turning craft about to give aid to other craft, if able, giving distress signal, following U.S. Coast Guard Rules of the Road for collision at sea;

Plow-in: reducing propeller pitch within 3 seconds of indication(s) to bring craft pitch to +.8 or more;

and following individual miscellaneous emergency procedures sequence with 100% accuracy.

13.6.1 Perform Flooding Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of water surface (wave height) and physical perception of roll, pitch, surge, heave or sluggish motion via change in craft attitude or listing under varying visibility, sea and wind conditions,

PERFORMANCE: perform flooding emergency procedures

STANDARDS: reacting to craft attitude change or indication(s) within 3 seconds, verifying N_2 set to MAX PWR to maintain maximum cushion, turning craft towards beach or shallow water and following flooding emergency procedures sequence with 100% accuracy.

13.6.2 Perform Man Overboard Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track or refueling, visual recognition of water surface and man overboard (or position alert from other crewmember),

PERFORMANCE: perform man overboard emergency procedures

STANDARDS: beginning craft slowdown to below hump speed and/or turnabout to victim position within 5 seconds of alert, lowering ramp to pickup only if sea state less than or equal to 2.

13.6.3 Perform Collision Emergency Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft having just collided with other craft or obstacle, visual recognition of water surface and other craft and physical perception of impact, roll, pitch, yaw, sway, surge and heave,

PERFORMANCE: perform collision emergency procedures

STANDARDS: reacting to situation within 3 seconds, verifying N_2 set to MAX PWR to maintain highest cushion possible, turning craft about to give aid to other craft, if able, giving distress signal and performing collision emergency procedure sequence with 100% accuracy following U.S. Coast Guard Rules of the Road for collision at sea.

13.6.6 Perform Plow-In Recovery

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition of water surface (and shoreline if approaching beach), aural recognition of pitch clicks, physical recognition of gingers telegraphing, pitch, roll vibration or negative surge and panel indication of pitch less than + .8 under varying visibility, sea states and wind conditions,

PERFORMANCE: perform plow-in recovery

STANDARDS: reducing propeller pitch within 3 seconds of indication(s) to bring craft pitch to + .8 or more.

13.7 Perform Miscellaneous Abnormal Conditions Procedures

CONDITIONS: Given an LCAC craft/simulator control station and the following conditions for individual miscellaneous abnormal conditions procedures:

Pre-Towing Checklist: craft disabled, visual recognition of fore and aft towing vessels/vehicles, visual recognition or effect of 2 nylon bridle legs, 2 nylon towing lines, 7 shackles, 2 pear links, and a pre-towing checklist;

Towing Over Water: craft disabled, visual recognition of fore and aft towing vessels, visual recognition or effect of 2 bridle legs, 2 tow lines, 7 shackles, 2 pear links, signal/radio man on lead towing craft and water surface, under varying visibility, sea and wind conditions;

APU Protective Shutdown: APU panel, aural recognition of protective shutdown or illuminated warning light on annunciator (MARCON) panel;

Main Engine Start Sequence Failure: during engine start, aural recognition of engine noise change or abnormality, rapid engine EGT rise, lit oil pressure warning light or other indication of automatic engine shutdown and a main engine start checklist;

PERFORMANCE: perform miscellaneous abnormal conditions procedures,

STANDARDS: Pre-Towing Checklist: performing and verifying performance of pre-towing checklist procedure sequence with 100% accuracy, clearance requested and obtained within 15 minutes.

Towing Over Water: operating at a maximum speed of 10 knots (on-cushion) or 5 knots (off-cushion), complying with requested power settings, and recognizing and reacting to all hand or radio signals with 100% accuracy.

Towing Over Land: operating at a maximum speed of 5 knots, avoiding uneven terrain or gradients, complying with requested power settings and recognizing and reacting to all hand or radio signals with 100% accuracy.

APU Protective Shutdown: setting APU START/STOP switch to STOP within 3 seconds of indication(s), and verifying APU condition before restart.

Main Engine Start Sequence Failure: setting engine PURGE/RESET switch to PURGE within 3 seconds of indication, allowing 50 seconds for engine coastdown, verifying engine start sequence box light is out and following main engine start sequence failure procedures sequence with 100% accuracy.

13.7.2 Perform Towing Operations

CONDITIONS: Given an LCAC craft/simulator control station, craft disabled, visual recognition of fore and aft towing vessels/vehicles, visual recognition or effect of 2 nylon bridle legs, 2 nylon towing lines, 7 shackles, 2 pear links, 2 pliers, 2 3lb. mallets, signal/radio man on lead towing vehicle and a pre- towing checklist under varying visibility, sea and wind conditions,

PERFORMANCE: perform towing operations

STANDARDS: operating at a maximum speed over water of 10 knots (on-cushion) or 5 knots (off-cushion) and over land at lead vehicle requested speed and otherwise consistent with prevailing winds, sea conditions, terrain and/or craft controllability.

13.7.2.1 Perform Pre-Towing Checklist Procedures

CONDITIONS: Given an LCAC craft/simulator control station, craft disabled, visual recognition of fore and aft towing vessels/vehicles, visual recognition of effect of 2 nylon bridle legs, 2 nylon towing lines, 7 shackles, 2 pear links, and a pre-towing checklist,

PERFORMANCE: perform pre-towing checklist

STANDARDS: performing and verify performance of pre-towing checklist procedure sequence with 100% accuracy, clearance requested and copied within 15 minutes.

13.7.2.2 Perform Towing Over Water

CONDITIONS: Given an LCAC craft/simulator control station, craft disabled, visual recognition of fore and aft towing vessels, visual recognition or effect of 2 bridle legs, 2 towlines, 7 shackles, 2 pear links and signal/radio man on lead towing craft under varying visibility, sea and wind conditions,

PERFORMANCE: perform towing over water

STANDARDS: operating at a maximum speed of 10 knots (on-cushion) or 5 knots (off-cushion), complying with requested power settings, and recognizing and reacting to all hand or radio signals with 100% accuracy.

13.7.2.3 Perform Towing Over Land

CONDITIONS: Given an LCAC craft/simulator control station, craft disabled, visual recognition of fore and aft towing vehicles, visual recognition or effect of 2 bridle legs, 2 towlines, 7 shackles, 2 pear links and signal/radio man on lead towing vehicle under varying visibility, sea and wind conditions,

PERFORMANCE: perform towing over land

STANDARDS: operating at a maximum speed of 5 knots, avoiding uneven terrain or gradients, complying with requested power settings and recognizing and reacting to all hand or radio signals with 100% accuracy.

13.7.3 Perform APU Protective Shutdown Procedures

CONDITIONS: Given an LCAC craft/simulator APU panel, aural recognition of protective shutdown or illuminated warning light on annunciator (MARCON) panel,

PERFORMANCE: perform APU protective shutdown procedures

STANDARDS: setting APU START/STOP switch to STOP within 3 seconds of indication(s), and verifying APU condition before restart.

13.7.4 Perform Main Engine Start Sequence Failure Procedures

CONDITIONS: Given an LCAC craft/simulator control station during engine start, aural recognition of engine noise change or abnormality, rapid engine EGT rise, lit oil pressure warning light or other indication of automatic engine shutdown and a main engine start checklist,

PERFORMANCE: perform main engine start sequence failure procedures

STANDARDS: setting engine PURGE/RESET switch to PURGE within 3 seconds of indication, allowing 50 seconds for engine coastdown, verifying (via deck hand) that engine start sequence box light is out and following main engine start sequence failure procedures sequence with 100% accuracy.

MISSION PHASE 14.0 TRAINING SPECIFIC TASKS

14.1 Perform Buoy Operations

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, moored to buoy or in stationary position 25 yards downwind of buoy, visual recognition and/or effect of linehandler, messenger line, shackle, mooring ring, bit and/or buoy and water surface and physical perception of yaw in buoy translation under varying visibility, sea and wind conditions,

PERFORMANCE: perform buoy operations,

STANDARDS: slowing approach speed to buoy to less than 10 knots by 100 yards distance downwind of buoy, monitoring line handler's position and impacting buoy at less than .1 feet per second or holding craft position to allow line handler to disengage mooring line and departing buoy at speed less then 5 knots or translating buoy at speed less than 5 knots, verifying N_2 set to 55%, propeller pitch reduced to $\pm$ 10° and translation $\pm$ 5° yaw.

14.1.1 Perform Buoy Approach

CONDITIONS: Given an LCAC craft/simulator control station, craft underway on track, visual recognition and/or effect of messenger line, shackle, mooring ring, bit, buoy and water surface under varying visibility, sea and wind conditions,

PERFORMANCE: perform buoy operations

STANDARDS: slowing approach speed to buoy to less than 10 knots by 100 yards distance downwind of buoy, monitoring line handler's position and impacting buoy at near zero speed.

14.1.2 Depart Buoy

CONDITIONS: Given an LCAC craft/simulator control station, craft moored to buoy, visual recognition and/or effect of messenger line, shackle, mooring ring, bit, buoy and water surface under varying visibility, sea and wind conditions,

PERFORMANCE: depart buoy

STANDARDS: holding craft position to allow line handler to disengage mooring line and departing buoy at speed less than 5 knots.

14.1.3 Translate Side to Side Using Buoy as Reference

CONDITIONS: Given an LCAC craft/simulator control station, craft in stationary position 25 yards downwind of buoy, visual recognition of water surface, and buoy and physical perception of yaw under varying visibility, sea and wind conditions,

PERFORMANCE: translate side to side using buoy as reference

STANDARDS: at speed less than 5 knots, verifying N_2 set to 55%, propeller pitch reduced to $\pm$ 10° and translation $\pm$ 5° yaw for 100 yards either side of buoy.

APPENDIX B

SIMULATION STATE-OF-THE-ART ASSESSMENT FOR AIR CUSHION VEHICLES

SIMULATION OF AN AIR CUSHION VEHICLE

BACKGROUND

The most complex training device for large air cushion vehicle (ACV) operators would be a full-mission simulator. Such a device has not been built, but would be analogous to the simulators currently in use for training both military and civilian aircrew in the operation of aircraft such as the B-52, the C-130, and the Boeing 747. The equipment provides a learning environment which is a reproduction of the conditions to be found in operation of the real-world vehicle.

In contrast to the real world, the environment in which a simulated vehicle operates is controllable by an instructor, who may introduce malfunctions in chosen vehicle systems and is assisted by computer to monitor the way in which the trainees respond to a learning experience.

This Appendix describes the components of a typical full-mission simulator for vehicles of a complexity comparable to a Landing Craft Air Cushion (LCAC). The state of applicable current technology is described along with modifications and extensions of established techniques required to simulate a large ACV.

In general terms, no difficulties are foreseen in the design and production of an LCAC simulator. There will inevitably be a tradeoff between the fidelity of simulation in some areas and cost. It must be emphasized that this is usual with complex vehicles, and underscores the necessity to avoid over-specification of cue fidelity.

SIMULATOR COMPONENTS

A typical full-mission simulator is made up of a number of related components, or modules. These components are described below.

<u>Trainee Station</u>. The trainee station is a full-scale replica of the compartment, in the real vehicle, in which trainees carry out their duties. It is usual for simulated trainee stations to be faithful in terms of internal shape, internal dimensions, seating arrangements, presence and layout of controls and displays, presence of viewing devices and transparencies, and any physical objects which restrict vision or movement in the actual vehicle.

It is usual to provide every display and control which is found in the real vehicle, although some infrequently used items, of low priority for training, may be non-functional.

Instruments, controls, and any devices which provide an out-of-the-window view are connected by suitable interfaces to the simulation computer, in which resides a mathematical model of the vehicle to be simulated. The computer ensures that all control inputs made by a trainee have an appropriate and realistic effect upon the readings of instruments, motion base activity, and the scene presented in the visual display(s).

Controls. In full-mission simulators, all controls which are present in the actual vehicle are reproduced in the simulator. They may be considered in two groups:

- Primary controls. These are controls with which the trainee continually interacts in order to affect the direction of travel or speed of the vehicle. Such controls have the physical appearance of those in the actual vehicle, and may be original equipment or be fabricated specifically for simulator use. When a number of identical simulators are to be built, the latter course of action is generally cheaper.

  Trainee operators use the primary vehicle controls as part of a psychomotor task involving displays, out-of-the-window, and kinaesthetic cues in order to keep the vehicle on its required track. Because these controls are part of a tracking task loop, and require continual delicate adjustment to maintain optimal accuracy, they must have the same control/display relationship in the simulator as in the actual vehicle. In addition, they must exhibit the same "feel" to the operator as in the vehicle, to prevent the formation of simulator-specific control strategies. This is achieved by the use of Control Loading Units, mechanically linked to each primary control. The Control Loading Units are typically hydraulic cylinders, into which fluid flow is controlled by valves and restrictors. These flow control devices are operated by the simulation computer, to give static friction, coulomb friction, hysteresis, and so on, that is similar to that of the actual vehicle for each point in its operating envelope.

- Secondary controls. These are the remainder of the levers, knobs, switches, etc., that are located at the trainee station. Most are functional, and are therefore connected to the simulation computer by means of an Interface system.

  Secondary controls may be either original equipment or be fabricated specifically for simulator use. The make-or-buy decision depends on the number of identical devices in the simulator, and the cost and availability of vehicle manufacturers' parts.

Instruments. Any large, complex vehicle, such as the LCAC, has a multitude of instruments to advise the operating crew of conditions both internal and external to the craft. Examples are:

- Engine performance and condition
- Hydraulics
- Electrical power generation
- Fuel state and flow
- Navigation.

In each of the groups, instruments in the simulator must have the same format as those in the actual vehicle. Two general formats are currently in use in complex vehicles:

- Conventional dial and pointer
- Cathode-ray tube or plasma panel based.

- Conventional. Until recently, the overwhelming majority of instruments fell into this category. For simulator use, it is necessary to achieve an appearance to the operator, and mechanical response, identical to that in the real vehicle. This may be achieved in two ways:

  - Use of actual vehicle instruments - In this approach, actual vehicle-standard instruments are procured from the original equipment vendor. They are therefore precisely the same, in terms of form fit

and function, as those in the vehicle itself. Such instruments are driven by electrical signals derived from an interface coupled to the simulation computer. In the case of instruments such as direct-reading pressure gauges, such a solution is not practical and the following approach is employed instead.

- Use of modified or simulated instruments - This technique is necessary for other than electrically operated instruments and may in fact be employed for any instrument. In the case of a pressure gauge, the pressure-sensitive mechanism and gearing would be removed from a real-vehicle instrument, to expose the drive to the indicating pointer. A small servomechanism, normally a D.C. servo, would be built into the instrument case and coupled to the pointer drive. The servo would be interfaced to the simulation computer, which would command servo position (hence indicated pressure reading). This technique may also be employed with electrically driven instruments which require complex signals that are not readily available. An example is the VHF Omni-Range (VOR) presentation, in which a 3-phase alternating current signal may be replaced by simpler signals.

In recent years, the modified-instrument method has been extended to include the building of entire instruments by simulator manufacturers. Not only simple instruments, but complex devices such as Horizontal Situation Indicators and Attitude Director Instruments are now constructed in this way. Careful attention to physical detail ensures that the instruments, when complete, have no visible differences in presentation compared to the original devices. There are, however, two major advantages. First, they are constructed in a more rugged fashion than are original-equipment instruments. Internal mechanisms, especially gear trains, are made of heavier, stronger, and more long-lasting materials than is possible in, for example, airborne equipment. This ensures that the simulated instrument is better able to endure the longer periods of operation of a simulator as opposed to the actual vehicle (a simulator may be in use for 16 hours per day, 240 days a year, for a lifespan of up to 20 years). Thus there is a potential total of about 77,000 operating hours for

each item of equipment aboard the simulator. Second, fabricated instruments are often cheaper to procure than even unmodified original equipment, whose price is raised by the strict quality control necessary for items to be installed in actual vehicles.

Audio Cues. In all complex vehicles, a variety of sounds are audible to the operators. Some sounds may be considered merely as a background noise, but others, such as those of the engine, are responsive to the operator's control movements and serve to cue the operator that a given control movement has produced a change in the controlled function. All sounds, whether background or responsive, are a part of the overall environment in which the operators perform their tasks, and are reproduced as far as possible to enhance the realism of a simulation.

Data for the reproduction of sounds are gathered by means of tape recorders, used when the vehicle is operated in a wide range of conditions. Specific recordings are made of the sounds emitted by particular devices of interest, such as engines, pumps, and aerodynamic noise sounds. The most common technique is to subject the tape recordings to a Fourier analysis, using a spectrum analyzer. By this means, each sound is reduced to an equivalent set of simple waveforms. Reproduction of the sounds is then achieved by a large number of voltage-controlled oscillators, each one being under the control of the simulation computer. By this means, each individual sound is controllable in terms of pitch, intensity, and frequency content in an independent manner which is not possible by the use of simple tape recorders or other straight-replay mechanisms. The output of the voltage-controlled oscillators is combined as appropriate, and passed through power amplifiers. Audio output is then achieved by means of loudspeakers, strategically placed to create a stereophonic effect to the operators. For example, the sound of a pump would be heard at its correct location in space rather than as an omni-directional sound.

In general terms, the advent of integrated circuits specifically dedicated to sound generation, and containing many oscillators and waveform--shaping components, has resulted in simulator audio systems becoming not only comprehensive but comparatively inexpensive.

Motion. In any complex vehicle which is controlled in real time by an operator, the cues to vehicle motion are very important. Although the conduct of a maneuver may be primarily by visual reference, either out-of-the-window or to instruments, motion cues have a vital alerting function. The human inner ear is sensitive to acceleration, and rate of change of acceleration. Cues from this mechanism are received very rapidly by an operator, and do not require the cognitive step -- and time delay -- of interpreting a visual display. Hence if a vehicle is, for example, to be controlled in a straight line, any tendency which it has to wander first be perceived by the operator as an acceleration cue. This alerting function serves to quicken the operator's response to his perception of visual cues -- in other words, he anticipates the visual cue before it becomes apparent in the out-of-the-window scene or on the instrumentation. The net result is to minimize the time for operator corrective response, hence the deviation of the vehicle from the required path.

In view of the above, it is an important feature of a vehicle simulator that some motion cueing is provided for the operator. This cueing must be accurately correlated with the vehicle dynamics and the visual presentations, but it does not necessarily have to be of the same magnitude as that in the vehicle for good transfer of training to occur.

A secondary, though important, requirement for motion in a simulator is to provide the vibration and minor motion cues which serve to give the operator an impression of being in a "live" system. Even when travelling in a steady-state condition, all vehicles exhibit vibration of some magnitude and the LCAC is no exception.

The most common method of providing motion cues in a simulator is to mount the entire trainee station on a "motion base". This is usually a hydraulically-powered platform, which is able to move in one or more directions, or degrees of freedom. There are six possible degrees of freedom:

Rotational - Pitch
Roll
Yaw

Translational - Heave (vertical)
Sway (lateral)
Surge (fore and aft)

Various combinations of these degrees of freedom have been provided by successive generations of simulator. Early motion systems were troublesome in that the hydraulic cylinders frequently leaked when seals wore out, there was high and to some extent unpredictable static friction leading to poor cue fidelity, and worst of all there were mechanical joints which sometimes developed play. This latter defect produced a distinct acceleration spike when the motion system changed direction, leading to highly unrepresentative cues and mechanical noise.

In recent years, most of the early problems of motion system design have been solved by the introduction of 6 degree of freedom "synergistic" devices. These are simple in concept. The trainee station is supported by six hydraulic cylinders, attached to the floor at their lower ends and to the trainee station at their upper extremities. They are arranged in pairs, in a triangular fashion, in such a way that movement of the trainee station in all six degrees of freedom is possible. Any movement of the trainee station requires motion of all six hydraulic cylinders, which cooperate in a complex manner. Thus the resultant motion of the trainee station is greater than the sum of the individual cylinder actions, which are therefore synergistic -- hence the name of the motion system. Such a device requires considerable computer support to ensure that the cylinder flow control valves are correctly operated to produce any given combination of extensions for each of the six "legs" of the motion system, hence attitude of the trainee station. The programs required, however, have been in constant use for almost a decade, and are now completely usable off-the-shelf.

This type of motion system is able to employ advanced cylinder design. The bearings are hydrostatic, and so have no significant static friction. There is virtually no fluid leakage problem, and cylinders have built-in safety devices for protection in the event of a runaway condition of a flow-control valve. Also included in each cylinder is an ultrasonic ranging mechanism which measures cylinder extension, for feedback to the motion control program in the computer. Mechanical bearings are needed only at the top and bottom of each cylinder. They are simple and robust, and can be made self-adjusting to prevent problems with wear-induced clearance and acceleration transients.

A typical off-the-shelf 6 degree of freedom motion system is one which has the performance shown in Table 1.

TABLE 1

6 DEGREE OF FREEDOM MOTION SYSTEM PERFORMANCE*

AXIS	EXCURSION	PEAK ACCELERATION	PEAK VELOCITY
Vertical	64 inches total $\pm$ 32 inches	$\pm$ 0.8g	20 $\frac{\text{inches}}{\text{sec}}$
Lateral	80 inches total $\pm$ 45 inches	$\pm$ 0.6g	24 $\frac{\text{inches}}{\text{sec}}$
Longitudinal	90 inches total $\pm$ 45 inches	$\pm$ 0.5g	24 $\frac{\text{inches}}{\text{sec}}$
Pitch	50 degrees total $\pm$ 25 degrees	$\pm$ 50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$
Roll	44 degrees total $\pm$ 22 degrees	$\pm$ 50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$
Yaw	56 degrees total $\pm$ 28 degrees	$\pm$ 50 $\frac{\text{degrees}}{\text{sec}^2}$	20 $\frac{\text{degrees}}{\text{sec}}$

*Based upon sinusoidal movement throughout the total excursion for each case, continuous duty cycle.

Alternative Motion Cueing Devices. In recent years, alternative motion cueing devices have been developed, to replace or complement the motion base described above.

The earliest was the "g-seat", developed for use in fighter aircraft simulators. This type of vehicle is unusual in its ability to subject an operator to sustained acceleration, (g). Motion bases produce g-force by acceleration over a limited physical displacement of the hydraulic cylinders, hence time. For this reason, they are unable to replicate with sufficient fidelity the forces acting on a pilot in, for example, a sustained pull-out from a dive.

The g-seat consists of a modified vehicle operator's seat. Modifications are the installation of a number of cushions in the pan and back of the seat, and the fitting of controllable retraction mechanisms to each of the seat harness elements. The cushions are formed of flexible airtight material, and are coupled through electrically operated valves to a compressed air source. The seat belt retractors also are powered through air motors, controlled by electrically operated valves. The air valves for both the seat cushions and the belt retractors are controlled by the simulation computer. Selective inflation/deflation of the cushions and tightening of the harness is employed to produce, for the trainee, an impression of acceleration force. For example, deflating the cushions and tightening the shoulder harness give the feeling of positive g (downward force). Inflating the left side of the cushion assembly but not the right gives the feeling of the vehicle in banking motion.

The g-seat technique may be used for a variety of vehicles, including an ACV, in which the operators are confined to a seat during vehicle motion. It has the advantage of requiring no large component external to the trainee station, and only a minimal amount of pneumatic power. Hence it is often easy to locate the trainee station and other simulator components in a trailer, relocatable classroom, or temporary building. This is not the case if a large external hydraulic motion system is chosen.

There are disadvantages in the use of the g-seat. First, the trainee must be confined to the seat, and must fasten all parts of the seat harness if adequate cueing is to be achieved. This latter constraint is sometimes of importance, as trainees may neglect to comply with

instructions to fasten harnesses securely. Second, the g-seat cannot impose vibration upon all control handles in the trainee station, as can a full motion system. Thus this motion direct to the controls, or the effect must be omitted entirely. Third, and perhaps most important, the g-seat cannot give a full range of acceleration cues to the trainee, who perceives the cues as being limited in variety and hence artificial. Because of this, g-seats have been limited in application to the simulation of high-performance combat aircraft. Here, the fact that they can successfully replicate the effects of prolonged high acceleration outweighs the disadvantage of a limited repertoire at the lower acceleration levels.

Other, more exotic motion cueing devices have included g-suits, in which air bladders are fitted to the legs of a suit which tightly envelopes the trainee. Upon the requirement to simulate high positive g-loading, the bladders are inflated and cause the suit to tighten further on the trainee's legs. This is reminiscent of the action of an aircraft anti-g suit, and provides a good cue to the pilot of a combat aircraft simulator. It is not, however, a cue which is required in ACV simulation.

Visual. In most vehicles, the out-of-the-window visual scene is of prime importance for control by an operator. Because of the richness of detail in the majority of scenes, however, it is also the most demanding aspect of vehicle operation to simulate.

The production of an out-of-the-window visual scene in a simulator may be regarded under two headings:

- Image Generation
- Image Display.

Image Generation - Over the years, a number of techniques have been developed for the generation of images in a visual system. The more important are:

- Camera/model and laser/model
- Photographic transparency

- Videodisc
- Caligraphic night only and night/dusk
- Computer Image Generation (CIG) for full daylight scenes.

Camera/model and laser/model. This technique has been in use for many years, and still finds application in the simulation of helicopters, weapons ranges, and surface vehicles such as tanks.

A three-dimensional model of an area of terrain is constructed from wood, plaster, fiberglass, or foam material. The topographical features such as hills, valleys, lakes, and roads are reproduced, at a scale factor which is typically 300:1 for surface vehicles, up to 2000:1 or even higher for fast aircraft. On the terrain base are placed scale model trees where appropriate, and modelled cultural features such as buildings, power lines, runways, vehicles, and even in some cases cattle. The model so constructed may accurately portray a particular area of real-world terrain or -- at a lower cost -- a non-representative area containing those features required for training in specific mission-oriented tasks.

The completed model is placed either horizontally or vertically, and is illuminated by a bank of bright lamps -- typically quartz-halogen. An optical probe is then positioned on or over the model surface, with its object lens or prism occupying the "eye position" of the simulated-vehicle operator. At the other end of the probe is fitted a closed-circuit television camera, which records the "operator's view" as seen through the probe. The probe and camera assembly is carried on a gantry, which is caused to move relative to the surface of the model under the control of the simulation computer. Thus the probe may "fly" over the model in the same way as an aircraft or surface vehicle, with the TV camera recording the view which would be seen by the vehicle operator. The output of the video system is displayed on a cathode-ray tube monitor, which is viewed by the trainee operator in the simulator.

Various optical devices in the probe allow the simulation of 360° change in heading of the simulated vehicle, movement in the rolling and pitching planes, and change in the focus of the device.

The camera-model technique has the advantage of providing a detailed image, in full color if required, with accurate perspective at low operator eye heights, as are found in surface vehicles. There are, however, disadvantages which limit the current application of this method:

- Models tend to be large and cumbersome, and require a large building to house them.
- Models represent only one fixed area, and cannot be easily exchanged.
- A large amount of expensive lighting power is needed. This in turn requires a lot of air conditioning in the simulator building.
- Despite high-intensity lighting and small-aperture probes, the depth of field available in the optical system is limited to an extent that makes it a noticeable deficiency in the system.

Some of these disadvantages have been overcome by the recent development of scanned-laser "cameras". In this approach, a mixed-color beam of laser light is projected along the probe, from the place previously occupied by the camera, and is emitted at the probe end in a scanned format. This beam illuminates the model in the cone of vision of the system, and the light is reflected away from the surface of the model. In the position formerly occupied by the lamps of a conventional camera-model system are mounted triads of photo-multipliers, one each for red, green, and blue light. These devices receive the laser light reflected from the surface of the model. The photomultiplier signals are arranged to provide the input of a conventional TV chain, whose output is shown on a monitor in the usual way. This technique has the advantages of low power requirement. It it has low running costs, requires minimal cooling, and gives a vastly improved depth of field. The other disadvantages associated with a model, however, remain.

The laser-based system is currently undergoing extended evaluation in a helicopter simulator designed for nap-of-the-earth flying.

A camera-model visual system is currently in use on the ship's bridge simulator installed at Marine Safety International, Long Island, N.Y. This system is unusual in that it employs a special probe which gives three side by side but contiguous fields of view, each 50 degrees

wide by 19 degrees high. It is further distinguished by its use of interchangeable model sections, representing specific harbors and areas of interest.

Photographic Transparency. In this technique, a camera is used to record either a real-world scene or to photograph a three-dimensional model from the operator's eye-point. Optical projection is then used to display the photographed scene, at very high resolution, to the trainees in the simulator.

If a single transparency is used, a limited amount of apparent motion of the simulator can be achieved by zooming the optical projection lens. This permits only limited movement in one direction, however, so is not suitable for a free-gaming situation as would be encountered in LCAC operation. A variation of this technique has been used on some ship's bridge simulators. In this case, direct projection of points of light is used to represent the lighting patterns of other vessels, buoys, and shore installations, in a nocturnal scene.

A further variation on the technique is to employ a cine camera to record a sequence of pictures as the camera moves in the gaming area. This method has been successfully used for aircraft landing simulation, where the camera was mounted aboard an aircraft which followed the optimum approach path to the runway. Optical methods have been developed to distort the displayed image sufficiently to reproduce the effects of a limited deviation by a student from the path described by the recording camera.

The technique encounters difficulty when operation in other than a fairly constrained area is involved. In such a case, a number of films, each taken from a different movement track, is required. Nevertheless, film-based visual systems have been used for maritime simulation over a wide gaming area, as the relatively low speed of ship movement makes film selection and changing possible.

Videodisc. The videodisc approach would be a use of newly-developed technology which is not yet in service on a simulator. A visual system based on the technique is, however, currently under development by Vought LTV for an aircraft simulator.

Essentially, the cine films described previously are replaced by a series of consecutive frames on a videodisc. The videodisc is played on a device having a TV-format output, and the picture is viewed on a cathode-ray tube monitor. Electronic methods are used to distort each frame of information if necessary to simulate an eye-point which is not precisely the location of the camera which recorded the videodisc image. When such distortion reaches a certain value, a new frame, recorded at a point closer to that required, is rapidly accessed. In a practical visual system, a number of simultaneously-operating videodiscs are required in order to reduce access time and expand the total data storage capability.

Such a system gives real-world scene detail, limited only by the resolution of the TV system employed with the videodisc. It is, however, still under development and the extent to which true free gaming can be achieved has still to be determined. In addition, a mechanism has still to be perfected for making multiple recordings on adjacent pathways. Such a mechanism is said by Vought LTV to be under development, and will be proprietary to that company.

Caligraphic night only and night/dusk. In the early 1970s, the disadvantages of camera-model and film-based visual simulation had become clear. At this time, powerful digital computers had become readily available at relatively low cost, and their memory capacity was considerable. These two factors led to the development, by a number of agencies, of computer-based visual systems.

The first devices allowed only the simulation of night-time scenes for use with aircraft simulators. A "model" of the lighting pattern of an airport runway, terminal buildings, and surrounding town was constructed in the computer's memory, instead of being tangible as in a camera-model system. The computer was then arranged to sample this model from the position in space occupied by the simulated aircraft. This sampling took account of the field of view of the visual system (typically 48° x 36°), the heading of the aircraft, its pitch, and roll. In essence, the computer calculated what part of the light-point model would be seen by the pilot of an aircraft located at the position, heading, and attitude of the simulator. The view thus calculated

consisted only of light points, as they were the only data stored in the computer memory, but the view was of very accurate perspective. It was updated typically at 30 frames per second, which allowed "motion" of the simulator across the light-point model at realistic speeds with no perceptible lag due to re-computation of each frame. The light-point pattern thus computed was displayed on a beam-penetration type cathode-ray tube monitor. Such a monitor operates on the stroke-writing, or caligraphic, principle in which the electron beam is turned on only when actually writing a light point on the screen. It is then turned off, moved to the next light point position, and turned on again. Such a device gives high resolution and good light-point brightness, at the expense of the inability to reproduce the color blue.

Simple caligraphic visual systems are adequate to reproduce the lights of buoys, ships, and the coastline in ACV Simulation. They would not, however, be capable of depicting a coastline, beach, surf, or docking with a mother ship, in other than a line-drawing or matchstick-figure fashion. Such basic systems are in use by Hydronautics, and by the Coast Guard, to give simple visual presentations on simulators for engineering use and for the development of operational procedures. These devices, however, are not training simulators and do not provide the detail necessary for such usage.

A development of the night-only visual system is the night/dusk device. In this, the "model" data base in the computer memory holds descriptions not only of light points but also of various surfaces such as the ground, sea, highways, buildings, and other vehicles. Calculations are performed, as in the night-only systems, to determine the information which should be displayed to a vehicle operator having regard to his position in the data base, heading, and attitude. The visual information is displayed, as before, on a beam-penetration cathode-ray tube monitor driven caligraphically. An important difference, however, lies in the use of the electron beam to paint, on the screen, not only light points but whole areas of light to represent the ground, buildings, and so on. Painting of these surfaces is achieved by direction of the beam to form a "mini-raster" in the area to be filled by a surface. Thus the electron beam is made to produce a

picture which is very similar to that seen in a domestic television set by use of the raster-scan technique. The differences are that the beam-penetration tube allows a very high spatial resolution, with the penalties of lower light output and lack of blue color when compared with domestic TV.

This "dusk" system has been extensively developed by the simulator manufacturers over the last few years, and it is possible to achieve an excellent rendering of either a night or a dusk/twilight scene with thousands of light points and hundreds of surfaces visible at any one time. The result is a slightly cartoon-like, but otherwise very realistic, view out of the simulator window.

The latest systems have a wide range of special effects and features. Lights may be directional, in various colors, and may flash or rotate as appropriate. As the simulated vehicle moves through the modelled area, lights and objects will appear and disappear behind solid objects, such as buildings or hills, just as in the real world. Surfaces may be textured to give good cues to motion and distance, and small features such as doors and windows become visible as, for example, a building is approached. The scene may also be made "live", under control of the simulation computer. Lights in towns may go on and off as in the real world, "traffic" can move on highways, and other vehicles which may pose a threat to the safety of the simulated vehicle may be present on a variety of relative courses to provide realism for collision-avoidance training. Simulators fitted with such visual systems are in widespread use in the aviation training community, and it is normal to employ several channels of visual scene, with the displays matrixed edge-to-edge to give a wide-angle view from the cockpit.

This technique is capable of expansion to provide the variety of visual information needed for ACV simulation, if a night- and dusk-only training regime is deemed to be adequate. A large number of data-base models can be held on the computer disc memory, to permit, for example, leaving a mother ship, transit to a beach, and return across the sea. It would be necessary to simplify the visual modelling of the sea, possibly by introduction of some random effect to approximate wave movement, but this could probably be achieved by a simulator manufacturer as part of a simulator-build program.

Computer Image Generation (CIG) for full daylight scenes. A more recent form of computer-based visual system is the full-color daylight type. As in the types discussed above, a "model" of an area of terrain is held in computer memory, and may represent either a real-world location or be representative of an area of interest. The model contains light points where required, but many more bounded areas, or surfaces, than the dusk type of system. Surfaces, like lights, may be in any color including blue, unlike caligraphic systems using beam penetration CRTs. This flexibility is achieved by the use of a shadow-mask type cathode-ray tube for information display. The tube is scanned in a raster format, over its entire area, in a way identical to that employed in domestic television. The use of a shadow-mask tube -- again, similar to that used in domestic TV -- permits the production of full color pictures at a high brightness, but limits the size of the smallest item of displayed information to the size of one triad of phosphor dots. Hence the full daylight type of system at present has an inherently poorer resolution than the caligraphically addressed night/dusk approach. It is of note that work is proceeding on a caligraphically-addressed shadow-mask type of display tube, which will permit higher resolution images than can currently be achieved. Such devices should be available by late 1982.

Although daylight CIG systems are capable of displaying many more surfaces than are the night/dusk devices, the fact that they may display a daylight scene means that an observer expects to see much more scene detail than he would notice at dusk. The real world is made up of a vastly higher number of surfaces and data points than can be computed and displayed in a visual system of this type. An observer, therefore, usually notices that the CIG scene appears to be rather "cartoonish" in nature. Newly-developed techniques for edge-smoothing, contouring, and surface texturing have gone a long way towards remedying this defect, and one may expect further improvement as the technology progresses.

A full-daylight CIG visual system is installed on the CAORF ship's bridge simulation facility at the National Maritime Research Center, King's Point, N.Y. It is rather limited in capacity by today's standards, being capable of displaying 200 lights and 900 edges in each computer output channel. However, a 5-channel arrangement is employed,

with the total display representing a horizontal field of view of 240°, by 14° vertically. Thus, with all channels in operation, a total of 1,000 lights and 4,500 edges can be displayed to an observer. In interpreting this figure one should bear in mind that a surface (e.g., the side of a building) is bounded by several edges and may contain many more edges for definition of windows, doors, and so on. Contiguous surfaces, such as adjacent fields in countryside, may share one or more common edges. Hence the number of edges required to form a given scene considerably outnumbers the surfaces which they describe.

Full-daylight CIG systems could undoubtedly provide a good rendition of the visual cues required for ACV operation. The only development required from present state-of-the-art would be to produce a model of waves and surf, together with providing sufficient edge-display capability to implement the model. This is within the capability of the major visual system manufacturers, and could be done as part of a simulator-build program.

Unfortunately, the cost of full-daylight CIG systems is much higher than that of night only and night/dusk systems. As a guide, the ratio is about 4 to 1 for existing aircraft simulation systems. Hence a 4-channel CIG system, giving four adjacent 48 degree wide visual channels (total of about 185° with overlapping areas) would cost somewhere in the region of \$6-7 million for a similar application. If a night/dusk caligraphic system were chosen instead, the cost would fall to somewhere in the region of \$1.6 million. To both of these costs must be added an amount for preparation of the ACV-specific visual data bases.

Image Display - The preceding section discussed the methods by which images may be generated in a simulator visual system. This section deals with the way in which those images are made visible to an observer. The principal methods employed for display are:

- Cathode-ray tube monitor
- Video projector
- Laser projector
- Direct optical projection

Cathode-ray tube monitor. As noted in the previous section (Image Generation), a cathode-ray tube monitor is used as the medium by which video signals are converted to light patterns, visible to an observer, in most camera-model and computer-generated visual systems. The monitor may be viewed by the observer in two ways.

First, the monitor may be mounted directly in the position occupied by a window transparency in the simulator. In other words, the window glass would be replaced by a TV-monitor screen. This configuration has the advantage of simplicity, but also some disadvantages which result in its use being rare:

- The largest practical and readily available size of CRT tube is 26 inches diagonal measure, so this is the largest window that can be filled by a screen (about 21 inches by 15 inches at 4:3 aspect ratio). The angle which such a size picture would subtend to an observer would depend upon the viewing distance from his eye. However, in order to obtain a 48 degree wide picture this distance would have to be only about 23.5 inches -- which is so short as to present mounting problems in most simulators.

- At the eye-to-screen distance quoted above, the ciliary muscles in an observer's eye would be in use, to focus the eye at about 23 inches. In addition, the eyes would converge as they do when reading a book. The net result would be conflicting signals to the observer's brain -- his eyes would indicate a very close visual scene, but intellectually he would try to believe in a much further distant scene. This conflict has been found to cause headaches and nausea in observers, when sustained over a long period in a simulated mission.

The second method of using a monitor is to provide a means of pseudo-collimation of the image. In essence, this involves the interposition of an optical mechanism between the CRT screen and the observer, sufficient to ensure that the rays of light reaching the observer's eye are essentially parallel. If this is achieved, the observer perceives the picture on the screen as being located at or near infinity. Hence the perceptual conflict noted above for direct viewing is

avoided. In practice, pseudo-collimation is very widely used, and gives an effective collimation distance of about 300-600 feet. Collimation may be achieved either by use of a fresnel lens system -- which is comparatively rare -- or by use of a concave mirror in which the image of the TV screen is reflected. This latter system is in widespread use in flight simulators, but has the disadvantage of a small exit pupil, so one display cannot be viewed in full by two observers seated side-by- side. Careful placement of two or more displays is therefore necessary, to ensure that each observer has a full field of view, derived from his own display.

It is possible to arrange a matrix of pseudo-collimated displays edge-to-edge, to give a continuous wide-angle field of view. The latest systems have zero gap between adjacent displays, and may be of almost any width in increments of about 48 degrees. It is more difficult to matrix displays both horizontally and vertically, and attempts to do so would result in non-standard hardware design and therefore a large cost impact. A vertical field-of-view of 36 degrees is therefore the maximum which can be obtained using standard devices with this technique.

Video Projection. Various devices have been developed for the projection of TV-format information onto a wide screen which is positioned some distance from the observer. This technique has the advantage that it is non-pupil-forming, and so may be viewed equally well by a number of observers at different positions (unlike the collimated CRT approach). It is therefore eminently suitable for use in the simulation of ship's bridges, and may be seen in operation at a number of maritime simulation facilities such as CAORF at King's Point, N.Y., and Marine Safety International, N.Y.

The mechanism used for the projection of the TV-image varies. At its simplest, the Eidophor projector is able to achieve a quite bright picture (about 5-7 foot-Lamberts on a screen 30 feet distant). This device gives a monochrome picture, but may be converted to color by the use of a color-wheel. In this application, a wheel carrying colored filters is placed in the beam of light from the projector. The wheel is caused to rotate synchronously with the projection signals, such

that one frame of video information is written on the screen with the red filter in position, the next with the green filter, and finally with the blue filter. These frames are written in such rapid succession that an observer perceives not three successive colored images but one multi-colored image. There is, however, a potential problem if a multi-colored item in the visual scene moves very fast in an angular sense -- it will be written on the screen in different colors in each successive location, and the result will be a blurring, or color smearing. The angular rate at which this occurs will depend entirely on the design of individual projection systems, and their field-sequential rate.

An alternative method of video projection involves the use of three high-brightness CRTs, or light sources modulated in a raster format by light-valves, one for each of the three primary colors red, green, and blue. Each of the light-emitting devices is focused on a screen which is placed in front of the observer, and carefully adjusted so that the video information from it overlays the picture from the other two devices. When this is done, a full-color picture is available on the screen. Unlike the field-sequential color wheel solution, this system is not sensitive to the speed of motion of an object. The major disadvantage of the technique is its sensitivity to vibration, which tends to misalign the optical systems and to shorten the life of the light-valves, if used. In effect, it means that some problems will be encountered if the technique is employed on a simulator fitted with a motion system, as it is usual to mount the projectors on the roof of the trainee station.

Laser Projector. Work is proceeding in industry to develop a commercially-viable projection system based on the use of laser light. In essence, the technique is similar to that described in the preceeding section, but the light sources are three single-color lasers. Each beam is caused to scan over the surface of a screen mounted in front of the observer, and as it moves in raster format a picture is built up. The lasers are modulated in brightness, in much the same way as is the electron beam in a cathode-ray tube.

The problems of beam deflection and modulation have presented considerable obstacles in the past, but they are probably very near an effective solution. This method of information display will almost certainly become available in the near future, but its cost is likely to remain high for some years. In exchange, it will offer a high resolution picture at an enhanced brightness level when compared with conventional projection methods.

Direct Optical Projection. This method of display also makes use of a screen, located in front of the observer. It is used primarily for the reproduction of transparencies and cine film, but is also employed for the production of light point images in ship's bridge simulation for nocturnal operation.

The projection devices are simple in nature, and rely upon the use of filters for color effects and brightness variation, zoom lenses for image size changes, and servo-mounted mirrors or prisms to provide movement of the projected image on the screen. This technique is simple, reliable, and effective, but of course is limited in scope to the visual information pre-programmed on the slide or film.

Radar. Closely allied to the simulation of the out-of-the-window visual scene is the synthesis of the display presented to the observer of a radar system located on board the simulated vehicle. Two major techniques are in use to achieve this:

Transparency based. In this approach, a photographic transparency is made of the radar returns to be expected in a particular geographical area. This transparency covers the area in which radar operation is desired, but is limited by the amount of information which may be obtained from the system on which the transparency is recorded. The transparency is then viewed by a flying-spot scanner, which is analogous to placing it in front of a TV camera and reduces the transparency to video format. Electronic techniques are then used to select a particular area of interest on this video output, and to move this area as the simulated vehicle moves in space. Target returns from other vehicles are

added electronically, and the entire video frame is displayed on a cathode ray tube mounted in the trainee's display unit.

Digital Radar. A newer, and more flexible technique than that discussed above is analogous to the digital visual systems for out-of-the-window scenes. An area of terrain, including any sea or beach thereon, is digitized in three dimensions at a small resolution (within several feet). Each digitized point is encoded for radar reflectivity, then stored in a mass storage unit such as a magnetic disc. When the radar is in operation, a mathematical process similar to that used in CIG visual systems is used to retrieve data from the disc, add target vehicles, and format the entire scene for presentation on the radar system display cathode ray tube.

The digital approach has the advantages, when compared with the transparency based technique, of high resolution over a gaming area which may include half a continent, maintenance of resolution at all scale factors, and complete flexibility to update the data base to reflect intelligence information for a proposed theatre of military operations.

Computer and Math Model.

Computer. The computer may be viewed as the heart of a full-mission simulator. It contains a mathematical model of the vehicle which is simulated, and of the environment in which that vehicle may be operated. All operations of the simulator controls are signalled to the computer, which then determines how the vehicle would react to each control operation in the prevailing environmental conditions, and having regard to any synthetic equipment malfunctions demanded by the instructor. The computer then transmits signals which modify the readings of instruments at the trainee station, alters the out-of-the-window visual scene content, generate new audio cues, and modify the motion system action. In addition to this, the computer may be used for assessment and recording of student performance against pre-set criteria, and the introduction of simulator-specific experiences such as the replay of mission segments.

It is now virtually universal for digital computers to be employed in the operation of sophisticated full-mission simulators. Digital

computers are compact, reliable, can process information accurately, and can operate rapidly enough for the purpose. A wide variety of machines has been employed for simulation, ranging from those originally designed for data processing to devices designed and built specifically for the purpose by the simulation industry. For any particular simulator, the builder will decide upon the optimum computer architecture to be employed. Depending upon the complexity of the vehicle to be reproduced, and its on-board systems such as radar, any number of computers from one upward may be used. Indeed, the latest development, by an English manufacturer, is the deletion of large mainframe computers and the use of a number of microprocessors, each dedicated to a particular on-board area such as engines, dynamics, navigation, and so on. This approach has resulted in a cost saving when compared with conventional systems, without sacrificing the flexibility of digital computation.

In recent years the industry has moved towards the use of 32-bit words to achieve increased accuracy, and this format is now widely adopted in lieu of the 16-bit words previously used.

The iteration rate at which the computer re-calculates the solutions to the math model depends on the sub-system of the vehicle which is concerned. It is normal, for example, to run a flight dynamics program at 30 to 60 hertz, but a program for digital control loading may need as much as 900 hertz to prevent discernible roughness in the output.

Math Model. The accuracy of the mathematical model of the simulated vehicle is the key to a reliable and usable simulation. Models are constructed using a mixture of information. First, a theoretical approach is used to understand the phenomenon or system under consideration, and to reduce it to a flow chart for program generation. Second, values are inserted into the program for all relevant parameters. These values may be derived from theoretical system analysis, but are equally likely to be obtained from empirical observation and measurement of the behavior of the vehicle under test conditions. Manufacturers' test data are usually very useful in the case of aircraft, where rigorous qualification procedures are followed during prototype testing. For other vehicles, however, it is usual for the simulator

manufacturer, in collaboration with the vehicle manufacturer and the customer, to use a vehicle in order to make a number of recordings and measurements in a variety of operational conditions. As examples, a wide range of tape recordings would be made for audio synthesis purposes, and recording accelerometers would be used to construct a model of the vehicle motion in response to control actions in a range of environments. Finally, the raw math models would be tried on the simulator and then modified in accordance with the manufacturer's experience, and in conjunction with Subject Matter Experts crew - qualified on the vehicle, to yield an acceptable facsimile of the real-world vehicle operation.

Instructor Station. The primary purpose of a simulator is to provide an environment which is conducive to the learning of specific vehicle-operation skills. This implies that it will be used as a tool in a program of training which is operated and administered by an instructor. By virtue of the fact that it has a computer as the central element, the flexibility and power of the simulator as a training device is extended beyond mere replication of a specific environment. In order to exploit this power, complex vehicle simulators have an area dedicated as an interface between the instructor and the machine. This is known as the Instructor/Operator Station (IOS).

For vehicles with physically small trainee stations - such as fighter aircraft - the IOS is usually located off-board and takes the form of a console. For larger multi-crew vehicles such as a transport aircraft or an LCAC, however, the preferred position is within the trainee station. This location permits an instructor to closely monitor the detailed actions of the trainee crew, without the mediation of readouts, closed-circuit TV, or other devices which are necessary to perform close monitoring from an off-board station. It is usually possible to place the instructor in a supernumerary crew or observer seat, and to provide him with a compact set of display and control devices to enable his interaction with the simulator. These devices must be positioned out of the normal lines of sight of the trainees, to prevent destruction of the illusion of being in an actual craft, and to avoid discovery by trainees of the nature of synthetic equipment malfunctions by reading the instructor's displays.

Until the early seventies, instructor station design was dictated by the philosophy of providing a discrete control device for each instructor input function, and a discrete display device for each output from the simulation computer. This resulted in the production of comparatively large and cumbersome instructor stations, which intruded on a considerable portion of the trainee station. Because of this, a move was made to multi-purpose controls and displays. In the most extreme form, the entire IOS became little more than an alphanumeric keyboard and a Visual Display Unit (VDU) - normally a small CRT monitor. This approach relied upon an instructor typing quite lengthy strings of letters and numbers into the system in order to effect a change in the simulator's operating parameters or to access a particular piece of information from the computer. Instructors were revealed as poor typists, and the arrangement called for a great deal of code learning in order to control the simulation. The end result was that much training in simulator-specific techniques was required of an instructor, and this detracted from his main task of teaching and monitoring the actions of his trainees.

Eventually, techniques were evolved to combine the instant-access advantage of the early designs with the compact flexibility of the multi-function systems. The solution was a hybrid, retaining the Visual Display Unit as the central feature of the IOS, and using it to display plain language messages, tables into which data such as fuel state and environmental information could be entered, and graphical performance assessment features such as track-keeping records. Interaction with the VDU is mainly by numeric keypad, choosing from a menu of options displayed on the screen. In the very latest systems, a selection of "soft keys", or buttons whose function is defined by labels displayed adjacent to them on the VDU, is provided for the most immediately needed options. Nevertheless, a group of hard-wired fixed function buttons and other controls are provided for those functions which must be immediately accessible without any VDU page selection. Examples are "freeze", change in out-of-the-window visibility, and emergency simulator stop. Potential future developments in this area include the use of touch-sensitive devices on the VDU screen to permit direct selection of "soft keys" drawn on the screen, and the use of voice-input devices by the instructor. A variety of instructional aids may be provided at minimal cost, as they are primarily applications of the simulation computer's power and flexibility. Some examples are:

Malfunctions. The failure of virtually any item of on-board equipment, either total or partial, may be simulated. Common examples are the occurrence of engine fire, generator failure, or navigation system inaccuracy. The effects of each malfunction are completely identical with those in the actual vehicle. Engine failure will, for example, affect audio system operation, fuel flow, electrical and hydraulic power, and thrust input to the vehicle dynamics model. A simulator for a Boeing 747 is programmed for over 1,000 malfunctions, which may be activated singly or in any combination possible in the actual aircraft.

Malfunctions may, of course, be activated at any time chosen by the instructor, be pre-programmed according to mission segment or other parameter, and be removed at will.

Freezes. Perhaps one of the most useful teaching aids in a simulator is the ability to freeze, or halt, computation of any or all of the simulated parameters. It is sometimes convenient, for example, to freeze the fuel state of the vehicle at a particular value, thus allowing continued operation of the engines indefinitely with no requirement for the trainee to monitor fuel contents remaining or the trim changes caused by fuel burn. By this means, the trainee's attention may be focused on other aspects of vehicle operation.

Other commonly used freezes include position freeze (geographical), and total freeze in which all computation is halted, and every display maintains the value which it had when the "total freeze" control was operated by the instructor. This latter is the most often used training feature on many simulators, and allows the instructor to "stop the world" to discuss a particular teaching point.

Crash. The simulation computer can be programmed to detect conditions which would be catastrophic in the real vehicle, such as "plow-in" on an LCAC. When these conditions are detected, the simulator will automatically enter total freeze, so the situation can be discussed. Various audio cues can be added to reinforce the point, and to condition trainee avoidance of the situation.

Record/Playback. This aid involves the recording, on a continuous basis, of all simulator parameters. It is usual to continually record, then erase all information recorded longer than about five minutes before the current moment. A recorded history is therefore always available, without action on the part of the instructor. At any time, the instructor may enter "total freeze", then select any time period over which he desires a replay of trainee actions. When "replay" mode is engaged, the stored parameter values are used to drive the simulator in the precise manner in which it was operated by the trainee over the time period in question. All instruments, the motion base, and the out-of-the-window display, are operational and the Control Loading Units attached to the primary controls cause them to move just as they were moved by the trainee. Thus a developing situation can be replayed and analyzed at leisure.

As an extension to this feature, example maneuvers can be recorded by an instructor at any time, stored on magnetic disc, then recalled and replayed at will to serve as demonstrations to students.

Environment. All parameters which are external to the simulated vehicle, but are considered in the math model, are capable of variation by an instructor for teaching purposes. These include ambient temperature and pressure, wind speed and direction, magnetic variation, navigation beacons, other vehicle presence and actions and, in the case of the LCAC, current and wave action.

Position display. This instructor aid involves the position of a graphical "map" on the VDU, with both salient navigational features and the simulated vehicle position indicated. A track history can be added if required, as a growing tail to the vehicle symbol. The map may be referenced to geographical landmarks, navigational waypoints, or other vehicles as required.

Performance assessment. The assessment of trainee performance has been attempted, with varying degrees of success, in a number of simulators. At its simplest, it consists of the storage of procedural checklists for tasks such as engine start, fuel handling, and so on. The operation of

each control by the trainee crew is signalled to the computer, and is compared with the pre-set checklist. Any omissions or transpositions are immediately obvious, and are signalled to the instructor. Alternative methods of achieving the end objective must be listed separately in the computer memory, for comparison, as must any expected patterns of error.

The assessment of dynamic control of the vehicle is more difficult. It requires that a detailed list of sub-tasks be drawn up for the mission segment under consideration, and that objective methods of testing for satisfactory performance be devised. For example, upper and lower limits of speed may be determined. This enables the computer to continuously test whether or not the simulator speed lies between the two threshold values, and is therefore acceptable. A large number of criteria are needed to specify performance in all but the simplest dynamic task, and a perennial problem is the assessment of "smoothness of control", i.e., a trainee may stay within error thresholds, but control the vehicle in a rough manner.

Automated training. Experiments have been made in which the performance assessment features discussed above have been linked to a student briefing facility. In this, a student is briefed to carry out a particular mission. This briefing is done by audio message, or by an on-board TV monitor carrying written and graphical instructions. During the mission, the student's performance is monitored by the performance assessment feature. A satisfactory performance brings praise, and a briefing for the next mission in the syllabus of training. Unsatisfactory performance, however, results in constructive criticism by way of the briefing system, and the chance to either repeat the mission or to carry out a task to exercise defective skill areas, as appropriate. A complex of UH-IH helicopter simulators, Device 2B24, has been operating along these lines at Fort Rucker, AL, for many years.

SIMULATION OF AN AIR CUSHION VEHICLE

In earlier sections of this Appendix, the component parts of a simulator were defined and described. This section discusses the application of those

components to the specific problem of simulating an air cushion vehicle, such as a LCAC.

Trainee Station

No difficulties are foreseen in the detailed specification, design, and fabrication of the trainee station. The station would contain seats for the operator, the assistant operator or engineer, and in the case of a full mission simulator, also for the radar operator. These seats would be correctly located in relation to the simulated controls and displays, within a compartment which accurately reproduced the interior shape and size of the ACV operator station. The compartment would probably be fabricated from a steel tube frame, clad on its interior with appropriately shaped panels. This approach would leave the exterior of the compartment free to accept cable bundles and electronic equipment racks, which would be mounted directly on the frame members. An alternative method would be to obtain, from the ACV manufacturer, an actual ACV operator compartment and to modify it as necessary to accept the wiring and interface equipment necessary for simulation.

The final configuration of the LCAC has not been settled. If, in the actual vehicle, the operator, engineer and radar operator are seated within the same compartment, then this arrangement should be followed in the simulator. However, if the radar operator should be located in a discrete compartment, as in the JEFF (B), his only contact with the other two operators would be by interphone. In this case, the radar operator's compartment may be quite separate from that occupied by the other two trainees. Depending upon the final ACV configuration chosen, this design freedom may enable a manufacturer to realize some savings in cost.

Controls

All primary controls which are present in the ACV must be fitted in the simulator, and be operational. Control Loading Units must be fitted, and programmed to present appropriate static and dynamic loads when they are operated.

The extent to which secondary controls should be operational, or merely dummy, must be determined when the configuration of the ACV is known in detail.

Techniques for production of the controls, both primary and secondary, are well established and are not a risk area.

Instruments

The LCAC will have conventional dial-and-pointer style instruments and newer CRT display instruments. It is assumed that all the instruments which will be present in the vehicle will be directly relevant to its operation, and will therefore be required in a full-mission simulator.

The precise mixture of real and simulated instruments will be decided by the simulator manufacturer, as the result of his normal make-or-buy analysis. However, completely standard techniques are involved for both types, and there is therefore judged to be no risk in this area of the simulation.

Audio Cues

It will be necessary for the simulator manufacturer to make a series of audio recordings aboard the ACV, as previously described, in order to ascertain the content of the audio cues required. Techniques for doing this, and the technology required for sound synthesis, are so well established that this is not seen to be a risk area.

Motion

It is evident that an ACV is subject to considerable acceleration, in any or all of the six degrees of freedom, during operation. Simulation of this motion is important for two reasons. First, it has the function of alerting the vehicle operator to impending changes in vehicle motion, and so is an important factor in simulation of the operator control loop. Second, it has the property of transforming a mere reproduction of the vehicle into a "live", credible, facsimile of the real world. Although the directions and relative magnitudes of acceleration cues must be "as vehicle", it has been found in aviation simulation that acceptable simulation for training purposes may be achieved with peak and average acceleration values which are considerably less than those found in the real vehicle. For this reason, the six-degree-of-freedom motion base described earlier has been adopted as virtually an industry standard assembly. It's performance, as noted previously, has been found to enable adequate training in aircraft simulators ranging from small helicopters to large transports. Although a full analysis of the accelerations

experienced in an ACV has not yet been carried out, it is believed that they will be comparable to -- say -- a helicopter flying nap-of-the-earth. For this reason, it is judged that the standard six-degree-of-freedom system will also be adequate for use on an ACV simulator.

The use of g-seats for motion simulation is at first attractive, as it enables a reduction in the size of building required for simulator installation. However, the requirement to ensure that crew members always wear a full restraining harness, including shoulder straps, to enable motion simulation is felt to be too restrictive. In this connection one should bear in mind that it is possible for crew members to release their seat belts in order to avoid restriction of movement, and that they will then experience little or no motion cueing. In such circumstances, the simulator would be unlike the real world, and negative training could easily occur. The g-seat is, therefore, not recommended.

If a six-degree-of-freedom motion base is employed on the simulator, no technical risk is involved as only standard parts would be employed.

Visual

The provision of out-of-the-window visual cues in the ACV simulator is, without doubt, essential. In considering how they should be provided, there are two main areas of concern -- image generation, and image display.

Image Generation. The ACV operates in two distinct visual environments. First, it operates over the sea or across open land, in which the elements of the visual scene are essentially simple and at a considerable distance from the vehicle operator. Typical elements in such a scene would be waves, other craft in the distance, the horizon, a surf line, ground, and bushes or scrub. This type of imagery can be readily generated by all types of visual system, with the exception of very basic night-only CGI. In order to achieve flexibility of movement, flexibility of scene content, and full daylight operation however, the choice becomes more limited. In such cases, satisfactory results may be achieved by the use of camera/model (and laser/model), and daylight CIG systems. However, if the camera-model solution is chosen there will be a problem in the provision of moving waves in the picture, plus the requirement to use a non-standard multi-channel optical probe to give an operator field-of-view greater than 48° horizontally.

The second ACV operational environment of note is that of close proximity to other vehicles and natural objects. Examples are the cases of docking with a well deck, coming alongside a ship, and operation on a beachhead beside another ACV or a tank. Such conditions are far more difficult to simulate, as they require a vastly greater amount of visual information to be generated and processed to give the correct view. In the well-deck for instance, the entire visual system display would be filled with details of the ship's plating, catwalks, ramps, mooring lines, and deck-mounted auxiliary equipment. It is likely that an ACV operator will process all this information, consciously or otherwise, when maneuvering his craft in this area. A simplified scene would give false cues, and probably result in an unacceptably high rate of approach to the docking position. This high level of detail in a wide-angle scene may be provided by a camera-model or laser-model system, although with the difficulty outlined above concerning a wide-angle probe. As relatively constrained approach paths to the well-deck and other objects could be taken during training, the use of videodisc or transparency-based techniques could also be applicable here. It is also possible to employ CIG techniques for this portion of the visual system, although considerable processing power will be needed to deal simultaneously with the multitude of data points to be displayed.

The approach of least technical risk is judged to be that of camera-model. The basic system is well established, if rather inefficient in its use of power and inflexible in nature. Some special design of the probe would be needed, to accommodate the required field-of-view of the system.

The use of CIG technology would pose little more technical risk than camera-model, and would probably be capable of providing an adequate picture to the observer. Some development work would be necessary to produce the visual effects of waves and surf, but this area is not seen to be a problem to an experienced manufacturer. The main disadvantage of this approach is its cost, which is likely to be at least twice that of a camera-model system.

Neither videodisc nor transparency-based technologies have significant technical risks associated with them, but they suffer from the lack of spatial flexibility described above.

Image Display. Unlike the large ocean-going ships, ACVs have an advantage in their simulation in that the operators are confined to static positions. Because they cannot walk about a large bridge, there is no need to provide a visual system which is non-pupil-forming, such as a large projection screen. It will be acceptable to confine the trainees, and their instructors, to fixed seats and to arrange for the display of video information only at the appropriate eye points. A suitable method of image display would be the use of collimated cathode-ray tube monitors, using standard techniques which have been available for many years. This approach would enable the production of a simulator whose dimensions, with the exception of the motion base, would not greatly exceed those of the trainee station only.

No technical risk is seen to be associated with the display of visual images.

Radar

As discussed earlier, the simulation of radar images may be achieved by either a transparency based or a digital system. In view of the likely need to update the scenario details of other vehicles, it is recommended that the digital technique be employed for an ACV simulation. In order to minimize costs, it is likely that an adaptation could be made to the recently-developed low-cost weather radar simulator attachments now in production by some manufacturers for aviation trainer use.

There is no technical risk associated with the adoption of full digital radar simulation, but some small cost risk in the adaptation of low-cost techniques for the ACV.

Computer and Math Model

Computer. The precise type of computer facility, and associated memory and peripherals, is a matter to be decided upon by the manufacturer of the ACV simulator. The facility chosen may consist of one or more mainframe computers, or the newly-developed distributed microprocessors. This latter approach is well suited to a training simulator, but caution must be exercised if the machine is to be used also for research purposes. In the latter case, a mainframe will be more appropriate, as data from all aspects of the simulation can more readily be sampled within a

within a single device than from distributed processors with limited interconnection. In evaluating the responses of proposed vendors of equipment, note should be taken of the vendor's approach to updating programs, and to ensuring adequate reserves of cycle time and memory to cope with such updates. Vendors should also be required to justify the rates at which their programs are run, in order to minimize stepping effects in the displays and motion base becoming apparent to the operator.

There is no technical risk associated with the provision of adequate computing power for ACV simulation.

Math Model. It will be necessary for the simulator vendor to construct a mathematical model of the craft, of the environment in which it operates, and their interaction.

As far as the craft is concerned, no difficulty is foreseen. In complexity, the LCAC will be somewhat simpler than a four-engine transport aircraft, as there are the same number of power plants but fewer on-board systems. A great deal of data such as engine and fan performance will be available from the craft manufacturer, and experimental tests and observation will readily provide that which may be missing. Thus there is no risk in constructing a model of the craft itself.

Modelling of the ground over which the craft operates is also simple, because there are fewer variable friction effects than in a surface vehicle simulation. The sea and surf, however, are much more complex problems. Wave action is well documented in hydrodynamics texts, and it is assumed that a suitable model for simulation purposes could be constructed with a significant amount of effort--hence risk and cost. When the wave breaks, however, the dynamic situation occurring is not well understood. Hence, rough, breaking seas and the surf zone are areas in which little relevant data exist to help the systems analysts who will construct the models. It is assumed that it will be possible to construct a model, adequate for simulation, based upon some semi-random effects for breaking waves and surf. This is undoubtedly a risk area, and several iterations of the model may be required in the finished simulator in order to produce acceptable effects. Hence there is likely to be a significant cost impact in this area of the simulation.

The interaction of the craft and the ground or sea beneath it is also an area in which little modelling has been done. It is most likely that a simulator manufactor will employ the empirical approach in constructing that portion of the model. In this case, an actual ACV would be instrumented with a variety of recording devices, including multi-axis accelerometers and systems to record control movement. The craft would be taken through a variety of maneuvers, on seas of various states, whilst control actions and corresponding vehicle responses were recorded. From these data, a model will be constructed. This technique is one which is frequently employed in aircraft simulation, and simulator vendors do not regard it as a high risk area.

Instructor Station

The instructor station should be placed in the trainee compartment, to permit ready monitoring of student actions. It is likely that a CRT-based station will be the most effective in the space available, and most simulator manufacturers have standard modules which will be suitable.

Training aids which should be incorporated in the station include Freeze, Fuel Freeze, Position Freeze, Reposition Craft, Graphical Map, Record/ Playback, and a number of malfunctions. The number and type of malfunctions must be decided upon when full details of the craft itself are known.

There is not seen to be any risk associated with development of a suitable Instructor Station.

APPENDIX C

ACVOTS TRAINING DEVICE FUNCTIONAL DESCRIPTIONS

FUNCTIONAL DESCRIPTION
FOR
LCAC COCKPIT FAMILIARIZATION TRAINER

I. PURPOSE OF DEVICE

A. The LCAC Cockpit Familiarization Trainer (CFT) will be utilized to train operator/engineer tasks which are repetitive in nature. Such tasks include performance of normal/abnormal operating procedures and other procedures typically conducted via use of checklists. The CFT will be employed to train operators/engineers in accomplishing 96 objectives in part or entirety. The following functional description is based on JEFF(B) data/information and may require modification at such time as the LCAC design freeze becomes effective.

B. The capability of the CFT includes facilitation of learning of various control, instrument, switch, and light cockpit locations. All switches, knobs, levers, rudder pedals, and the control yoke will be present in the configuration. These controls, however, will be non-functional to the extent that they will not be capable of being actuated. Nor will they respond to operator inputs.

C. The CFT will be employed as a refresher training device for LCAC operators/engineers prior to their reassignment to a unit. It will also assist in proficiency maintenance of current LCAC operators/engineers.

II. TRAINING OBJECTIVES

A. Analysis results show that 293 out of 946 individual behaviors can be trained in the CFT to the level of mastery required of LCAC operators/engineers. An additional 550 behaviors may be practiced at the familiarization level. Further, CFT utilization will result in the following training benefits:

1. Provides the operator/engineer the opportunity for indepth study of cockpit instruments, development of required procedural skills, and effective scanning techniques in the context of a static environment.

2. Allows for assessment of operator/engineer level of performance on procedural tasks prior to training in the actual craft.

B. Training objectives for the LCAC CFT are as follows:

1. Reinforce trainee knowledge related to the characteristics, capabilities, and limitations of the LCAC.

2. Reinforce basic "in craft" pre-mission, underway, and post-mission procedures for both normal and emergency/abnormal conditions.

3. Provide trainee with knowledge required to effectively locate, identify and state function of cockpit controls, instruments, switches, and lights.

C. Specific tasks/subtasks to be trained through utilization of the LCAC CFT are listed below:

3.1	Perform Pre-mission Checklist Procedures
3.1.53	Direct Operating Crew Station Manning
3.2	Start Craft
3.2.1	Perform Power-off Checklist Procedures
3.2.2	Perform APU Start Checklist Procedures
3.2.3	Perform Pre-start Checklist Procedures
3.2.4	Perform Main Engine(s) Start Checklist Procedures
3.3	Perform Pre-Underway Checklist Procedures
3.4	Perform Lift-off and Hover Checklist Procedures

4.1	Transit from Land to Water
4.1.1	Obtain Clearance as Required
4.1.2	Maneuver to Outbound Heading
4.1.3	Perform Land to Water Transition
4.1.3.1	Perform Ramp or Slipway to Smooth Water Transition
4.1.3.2	Perform Beach to Smooth Water Transition
4.1.3.3	Perform Beach to Surf Transition
4.2	Exit Wet/Dry Well (Self-Propelled)
4.2.1	Exit Wet Well (Self-Propelled)
4.2.2	Exit Dry Well (Self-Propelled)
4.3	Perform Station-Keeping
4.3.1	Perform Single Station-Keeping
4.3.2	Perform Formation Station-Keeping
4.4	Disengage from Ship
5.1	Perform Transition Over Hump
5.2	Change Course
5.2.1	Change Course Upwind
5.2.2	Change Course Downwind
5.2.3	Change Course Crosswind
5.5	Perform Mission-Dependent Tasks
5.6	Perform Underway Main Engine Water Wash
5.7	Perform Normal Stopping (Over Water)
5.8	Come Off-Cushion (Over Water)
5.9	Operate in Boating Mode
5.10	Come On-Cushion (Over Water)
6.1	Transit Water to Land
6.1.1	Perform Smooth Water Approach

6.1.2	Perform Surf Approach
6.2	Fly Up a Slope
6.3	Fly Across a Slope
6.4	Hold Craft on Track in Yaw Moment
6.5	Cross Obstacles
6.6	Perform Normal Stopping (Over Land)
6.7	Come Off-Cushion (Over Land)
6.7.1	Come Off-Cushion Level
6.7.2	Come Off-Cushion On Slope
7.1	Supervise Unload
7.2	Perform Lift-off and Hover Checklist Procedures
8.1	Transit From Land to Water
8.1.1	Obtain Clearance as Required
8.1.2	Maneuver Craft to Outbound Heading
8.1.3	Perform Land to Water Transition
8.1.3.1	Perform Beach to Smooth Water Transition
8.1.3.2	Perform Beach to Surf Transition
9.1	Perform Transition Over Hump
9.2	Change Course
9.2.1	Change Course Upwind
9.2.2	Change Course Downwind
9.2.3	Change Course Crosswind
9.5	Perform Mission-Dependent Tasks
9.6	Perform Underway Main Engine Water Wash
9.7	Perform Normal Stopping (Over Water)
9.8	Come Off-Cushion (Over Water)
9.9	Operate in Boating Mode

9.10	Come On-Cushion (Over Water)
10.1	Fly Up To Moving Ship
10.2.2	Moor To Ship at Anchor (or Pier)
10.3	Refuel/Reload Craft
10.3.1	Perform Underway Refueling
10.3.2	Reload Craft (at Anchor)
10.4	Enter Well Deck (Self-Propelled)
10.5	Transit Water to Land
10.5.1	Perform Smooth Water Approach
10.5.2	Perform Surf Approach
11.1	Come Off-Cushion (Over Land)
11.2	Perform Craft Securing Checklist Procedures
11.2.1	Perform Equipment Shutdown Procedures
11.2.2	Perform Engine Shutdown Procedures
11.2.3	Perform APU Shutdown Procedures
11.3	Perform Refueling
11.4	Perform Mission Log Completion
13.1	Perform Emergency Stopping
13.1.1	Perform Emergency Stopping Over Land
13.1.2	Perform Emergency Stopping Over Water
13.2	Perform Fire Emergency Procedures
13.2.1	Perform Engine Fire Emergency Procedures
13.2.2	Perform APU Fire Emergency Procedures
13.2.3	Perform Craft Fire Emergency Procedures
13.2.4	Perform Deck/Cargo Fire Emergency Procedures
13.3	Recognize and React to Propulsion Power Loss Emergencies
13.3.1	Perform Single Engine Failure Emergency Procedures

13.3.2 Perform Multiple Engine Failure Emergency Procedures

13.3.3 Perform Transmission Failure Emergency Procedures

13.3.4 Perform N2 Govern Failure Emergency Procedures

13.3.5 Perform Fueling Failure Emergency Procedures

13.3.6 Perform Fuel System (Main Engines) Emergency Procedures

13.3.7 Perform Fuel System (APU) Emergency Procedures

13.4 Recognize and React to Lift System Failure Emerg. Procedures

13.4.1 Perform Cushion Failure Emergency Procedures

13.4.2 Perform Keel/Lateral Stability Bags Loss Emerg. Procedures

13.4.3 Perform Loss of Lift Fan Emergency Procedures

13.5 Recognize and React to Degradation of Craft Control

13.5.1 Perform Control System Failure Emergency Procedures

13.5.2 Perform Propeller Failure Emergency Procedures

13.5.3 Perform Rudder Actuator Failure Emergency Procedures

13.5.4 Perform Bow Thruster Failure Emergency Procedures

13.5.5 Perform APU Failure Emergency Procedures

13.5.6 Perform Generator Failure Emergency Procedures

13.6 Perform Miscellaneous Emergency Procedures

13.6.1 Perform Flooding Emergency Procedures

13.6.2 Perform Man-Overboard Emergency Procedures

13.6.3 Perform Collision Emergency Procedures

13.6.6 Perform Plow-in Recovery

13.7 Perform Miscellaneous Abnormal Procedures

13.7.2 Perform Towing Operations

13.7.2.1 Perform Pre-Towing Checklist Procedures

13.7.2.2 Perform Towing Over Water

13.7.2.3 Perform Towing Over Land

13.7.3 Perform APU Protective Shutdown Procedures

13.7.4 Perform Main Engine Start Sequence Failure Procedures

14.1 Perform Buoy Operations

14.1.1 Perform Buoy Approach

14.1.2 Depart Buoy

14.1.3 Translate Side-to-Side Using Buoy as Reference

III. DEVICE DESCRIPTION

A. Characteristics of Device

The CFT will be a static replication of the LCAC cockpit. It will contain all controls and instruments located in the operator/ engineer crew stations. Although not designed to simulate the dynamic characteristics of the LCAC, the CFT will present functionally correct layouts of all consoles and panels which the operator/engineer would interact with in the actual craft.

B. Requirements of the Device

The CFT will contain one trainee station. Since the controls and instruments are not operable, a separate instructor station for use in monitoring trainee inputs/responses is not necessary or required. Training procedures will include all skills and techniques required to familiarize trainee with cockpit layout and the procedural tasks of the following phases of operation:

1. Pre-launch
2. Depart
3. Transit Water (loaded)
4. Transit Beach
5. At Beach
6. Depart Beach
7. Transit Water (unloaded)
8. Reconfigure
9. Post Mission

10. Emergency/Abnormal Condition
11. Training Specific Tasks

The CFT will not be capable of simulating any environmental/tactical variables or situations.

C. Performance Parameters

The CFT will train 96 various operational procedural tasks. These procedures will range from APU start procedures to power-off procedures. Also included will be the complex/critical procedures involved in control of the craft in various mission modes. The CFT will not provide performance parameters associated with the use of LCAC sensors. Nor will it simulate interaction with other types of crafts. However, critical tasks/procedures requiring operator/engineer interaction can be rehearsed to various proficiency levels with the absence of high degrees of fidelity.

D. Performance Capabilities

The CFT will possess no automation in regard to trainee performance measurement. Student scoring will be conducted by the instructor via observation. Instructors will score:

1. System identification and location of controls, switches, instruments, lights, etc.

2. Practice of procedures to be employed for various missions and tasks.

3. Operator/engineer interaction requiring simultaneous/sequential control inputs. (Note: Actual control inputs will not be measurable.)

Student scoring will allow the instructor to critique trainee performance in a systematic fashion, and will result in evaluation/assessment of operator/engineer proficiency for the various procedures being trained.

E. Instructor Station

Separate instructor stations will not be required for the CFT since there will be no provisions for manipulating environmental/tactical conditions or required control responses. Further, since assessment of psychomotor skills involves control actuation/manipulation, only the identification of the procedures employing the psychomotor skills will be measured in the CFT and will vary depending on the task to be performed.

F. Trainee Station

1. The trainee station will be a replica of the LCAC control station cockpit. Device simulation will provide for duplication of all controls, instruments, switches, and lights in order to familiarize the trainee with their locations. All switches, knobs, lever, gages, the control yoke, and rudder pedals are present in configuration but will not allow for actuation by, or response to, operator inputs.

2. Simulation of the entire LCAC control station cockpit will be included in the trainee station. Sections of the cockpit, their associated panels, displays, and indicators are as follows:

   a. Port side

      (1) Ramp Control Panel

         (a) STERN UP/OFF/DN switch
         (b) STERN CLOSED light
         (c) BOW CLOSED light
         (d) BOW UP/OFF/DN switch

      (2) Fuel Condition Panel

         (a) MAIN VALVE OPEN/CLOSE switch
         (b) OVERFILL light
         (c) PRESSURE IN NOZZLE light
         (d) PRESSURE IN MANIFOLD light
         (e) FLOW INTO STRIPPING TANK-PORT light
         (f) FLOW INTO STRIPPING TANK-STBD light
         (g) PORT FILL light
         (h) STBD FILL light

(i) TANK VALVES OPEN/CLOSE switches
(j) DRAIN VALVE - PORT MAIN switch
(k) Port Main DIRT light
(l) Port Main WATER IN FUEL light
(m) DRAIN VALVE - PORT APU switch
(n) Port APU DIRT light
(o) Port APU WATER IN FUEL light
(p) DRAIN VALVE - STBD MAIN switch
(q) Stbd Main DIRT light
(r) Stbd Main WATER IN FUEL light
(s) DRAIN VALVE - STBD APU switch
(t) Stbd APU DIRT light
(u) Stbd APU WATER IN FUEL light
(v) FUEL FILTER CONDN lights
(w) ENG OIL FILTER CONDN lights

(3) Console

(a) INST. button
(b) LTS. button
(c) HF switch
(d) VHF switch
(e) VHF-M switch
(f) UHF switch
(g) HF/VHF switch
(h) ADF switch
(i) VOL knob
(j) Rotary Selector knob
(k) AC VOLTS meter
(l) VOLTS PRI/SEC switches
(m) GEN LOAD meter
(n) GEN ON-OFF/RESET-TEST switch
(o) AUTO DROPOUT ORIDE/NORM switch
(p) GROUND FAULT meter
(q) EXT POWER switch
(r) DC VOLTS meter
(s) DC AMPS meter
(t) AUTO DROPOUT ORIDE/NORM switch
(u) MAIN TANK VALVE switches
(v) LOW PRESS lights (port side)
(w) Port PRIMARY/STANDBY switch
(x) AUTO/MAN RESET switch
(y) Starboard PRIMARY/STANDBY switch
(z) LOW PRESS lights (starboard side)
(aa) FUNCTION SELECTION rotary switch
(bb) SEQUENCE switch (port side)
(cc) VALVE OPERATE switch
(dd) SEQUENCE switch (starboard side)
(ee) INSTRUMENT rotary switch
(ff) NAV switch
(gg) ANCHOR switch
(hh) BCN switch
(ii) CARGO switch

(jj) ON/OFF/STOW switch
(kk) SEARCHLIGHT EXTEND/RETRACT switch
(ll) AUDIO ON/OFF switch

(4) Main Instrument Panel

(a) LUBRICATION OIL STATUS panel
(b) OIL TEMP DEGREES F. indicator
(c) OIL PRESS PSIG indicator
(d) RADIO MAGNETIC indicator
(e) SPEED KNOTS indicator
(f) MASTER CAUTION light
(g) MASTER FIRE light
(h) FUEL QTY indicators
(i) FUEL MAN F, PRESS indicators
(j) APU ENGINE PERCENT RPM indicators
(k) APU EGT DEGREES F indicators
(l) NO. 1 APU CRANK/OFF switch
(m) NO. 1 APU START/STOP/RUN switch
(n) NO. 1 APU T/R PWR - BAT PWR switch
(o) NO. 2 APU CRANK/OFF switch
(p) NO. 2 APU START/STOP/RUN switch
(q) NO. 2 APU T/R PWR - BAT PWR switch
(r) ENGINE HEALTH MONITOR display units

b. Center Console

(1) Top Section

(a) BT switch
(b) R switch
(c) PROPS PORT switch
(d) PROPS STBD switch
(e) VERNIER PITCH switch
(f) OPER/STOW MODE switch
(g) FWD/REV MODE switch
(h) PORT gage
(i) STBD gage
(j) ENGINE MASTER switch
(k) Annunciator Panel
(l) DE-ICE switch
(m) WASH switch
(n) WIPER switch
(o) Wiper Control rotary switch
(p) DECK PWR OVED switch
(q) ZONE A TEST switch
(r) ZONE B TEST switch
(s) ZONE C TEST switch
(t) COUPLING R-BT switch
(u) COUPLING BT-R switch
(v) FRICTION wheel
(w) N_2 PORT ENGS lever
(x) N_2 STBD ENGS lever

(y) PORT PROP lever
(z) STBD PROP lever
(aa) FRICTION wheel

(2) Lower Section

(a) Fire Pull Handles
(b) Engine 2 PURGE/RESET switch
(c) Engine 2 START/STOP switch
(d) Engine 2 N_2 BRAKE switch
(e) Engine 4 PURGE/RESET switch
(f) Engine 4 START/STOP switch
(g) Engine 4 N_2 BRAKE switch
(h) Engine 3 PURGE/RESET switch
(i) Engine 3 START/STOP switch
(j) Engine 3 N_2 BRAKE switch
(k) Engine 1 PURGE/RESET switch
(l) Engine 1 START/STOP switch
(m) Engine 1 N_2 BRAKE switch
(n) FRICTION wheel
(o) ENG 2 throttle
(p) ENG 4 throttle
(q) ENG 3 throttle
(r) ENG 1 throttle
(s) FRICTION wheel
(t) ARM switch
(u) TEST RELAY 3 switch
(v) TEST RELAY 2 switch
(w) TEST RELAY 1 switch
(x) ALIGN TEST B button
(y) ALIGN TEST A button
(z) RESET button
(aa) B/T 2 light
(bb) B/T 1 light
(cc) RUDDER 2 and 4 lights
(dd) RUDDER 1 and 3 lights
(ee) PROP 2 light
(ff) PROP 1 light

c. Starboard Side

(1) Console

(a) LTS buttons
(b) HF SWITCH
(c) VHF switch
(d) VHF-M switch
(e) UHF switch
(f) HF/VHF switch
(g) ADF switch
(h) VOL knob
(i) Rotary Selector knob
(j) Gyro Synchronization indicator

(k) SLAVED/FREE SWITCH
(l) PUSH TO SET knob
(m) Thumbwheel Selector
(n) SELECTOR rotary switch
(o) PWR HI/LO switch
(p) SQUELCH knob
(q) MEGACYCLES knobs
(r) RCVR TEST button
(s) VHF-FM selector knob
(t) AUDIO knob
(u) 48.75.95 MHZ/30.47.95 MHZ FREQ BAND switch
(v) POWER OUTPUT HIGH/LOW switch
(w) THERMOSTAT knob
(x) THERMOSTAT OVERRIDE switch
(y) CONTROL BREAKER switch
(z) MAIN BREAKER switch
(aa) MASTER switch
(bb) SELECTOR switch
(cc) INSTR rotary transformer switch
(dd) CONSOLE 28V rotary switch
(ee) DOME RED ON/OFF switch
(ff) DOME WHITE ON/OFF switch
(gg) CONSOLE 115V rotary switch
(hh) RED ON/OFF button
(ii) WHITE ON/OFF button

(2) Main Instrument Panel

(a) AFT FUEL pull handle
(b) FWD FUEL pull handle
(c) LUBE OIL VALVES - PORT PROP OPEN/CLOSE switch
(d) LUBE OIL VALVES - PORT FWD OPEN/CLOSE switch
(e) LUBE OIL VALVES - PORT AFT OPEN/CLOSE switch
(f) LUBE OIL VALVES - STBD PROP OPEN/CLOSE switch
(g) LUBE OIL VALVES - STBD FWD OPEN/CLOSE switch
(h) LUBE OIL VALVES - STBD AFT OPEN/CLOSE switch
(i) STBD CLUTCH ENGAGE/DISENGAGE switch
(j) PROP PITCH indicator
(k) PORT CLUTCH ENGAGE/DISENGAGE switch
(l) WIND SPEED KNOTS indicator
(m) EGT, DEGREES, FX100 indicators
(n) N_2, PWR, % RPM indicators
(o) N_1 GG, % RPM indicators
(p) MASTER CAUTION light
(q) MASTER FIRE light
(r) RADIO MAGNETIC INDICATOR gage
(s) ELAPSED TIME clock
(t) SEA COND ROUGH/CALM switch
(u) PITCH indicator
(v) ROLL indicator
(w) RATE OF TURN DEG/SEC indicator
(x) Control Wheel
(y) MIC-INTERCOM switch

(z) TRIM REL switch
(aa) SPEED RADAR display

3. Although the cockpit features described above will be included in the CFT, display readout information will remain static. That is, information will not change since operators cannot actuate or manipulate controls or input devices.

4. No device special effects will be simulated or incorporated in the CFT.

5. System failures/malfunctions will not be simulated in the CFT. However, the CFT (within the constraints of its static presentation) will allow the trainee to practice emergency/abnormal procedures which would be performed during periods of the following system failures/malfunctions:

a. Emergency stopping over land/water
b. Engine fire emergency
c. APU fire emergency
d. Craft fire emergency
e. Deck/cargo fire emergency
f. Single engine failure
g. Multiple engine failure
h. Transmission failure
i. N_2 Govern failure
j. Fueling failure
k. Fuel system (main engines) failure
l. Fuel system (APU) failure
m. Cushion failure
n. Keel/lateral stability bags loss
o. Loss of lift fan
p. Control system failure
g. Propeller failure
h. Rudder actuator failure
s. Bow Thruster failure
t. APU failure
u. Generator failure
v. Flooding emergency
w. Man-overboard emergency
x. Collision emergency
y. Plow-in recovery emergency
z. Towing operations over land/water
aa. APU protective shutdown failure
bb. Main engine start sequence failure

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Intended utilization of the CFT will be 8 hours/day, 5 days/week, and 52 weeks/year as required to meet the training specified in the curriculum.

B. The life expectancy of the device, based upon the training requirements, will depend on the number and types of LCAC change. Since the final LCAC design is still evolving, it is anticipated that many update changes will be required, particularly during the first year of device implementation.

C. Periods of unusually high and/or low device utilization will be identified following completion of the underway syllabus and lesson specifications.

D. Actual craft control practice will not occur in the CFT. Thus, there will be little, if any need to procure or integrate alternate systems/subsystems due to failure during training.

E. Types of CFT exercises and time limits will be estimated and finalized after completion of lesson specification and underway syllabus definition.

FUNCTIONAL DESCRIPTION

FOR

LCAC PART-TASK TRAINER 1-A

I. PURPOSE OF THE DEVICE

A. The LCAC Part-Task Trainer 1-A (PTT1-A) will be utilized to train LCAC operators and engineers to perform proper master circuit breaker panel checks. The PTT1-A will be employed to train operators/engineers in accomplishing only one objective. The following functional description is based on JEFF(B) data/information and may require modification at such time as the LCAC design freeze becomes effective.

B. The PTT1-A will have the capability of familiarizing the LCAC operator and engineer with the components of the circuit breaker panel. Further, it will provide those individuals an opportunity to practice circuit breaker check procedures.

C. The PTT1-A will be employed as a refresher training device for LCAC operators/engineers prior to their reassignment to a unit. It will also assist in proficiency maintenance of current LCAC operators and engineers.

II. TRAINING OBJECTIVES

A. Analysis results indicate that only one behavior can be trained in the PTT1-A to the level of mastery required of LCAC operators/engineers. Training will provide:

1. Operators and engineers with circuit breaker panel check procedure familiarity, and

2. Means for assessing operator/engineer level of performance on the circuit breaker panel check procedure.

B. Training objectives for the PTT1-A are as foloows:

1. Reinforce trainee knowledge related to one portion of the pre-mission checks procedures.

2. Provide trainee with the knowledge required to effectively perform circuit breaker panel check procedures.

C. Only one subtask will be trained through utilization of the PTT1-A. That subtask is 3.1.52.2 select circuit breakers IN.

III. DEVICE CHARACTERISTICS

A. Characteristics of Device
The PTT1-A will be a pictorial representation of the LCAC circuit breaker panel. It will present a representation of the circuit breakers, but not panel location within the LCAC control stations. The PTT1-A will not be capable of simulating any other task, nor will it simulate any environmental conditions.

B. Requirements of the Device
The PTT1-A will be composed of one trainee station. Training procedures will include skills and techniques required to familiarize the trainee with circuit breaker checks/procedures during the prelaunch phase of operation. The PTT1-A will not have the capability (nor the requirement) of simulating any environmental/tactical variables or situations.

C. Performance Parameters
The PTT1-A will not possess any automation in regard to trainee performance measurement. Student performance measurements will be accomplished via instructor observation. Estimated performance requirements will be made following media selection and syllabus

development. Specific requirements will be established after lesson specifications have been defined and completed.

D. Instructor Station

There is no requirement for a PTT1-A instructor station. Instructors will not be required to manipulate either device performance characteristics or environmental conditions, nor will such manipulations be possible.

E. Trainee Station

1. The trainee station will be a pictorial representation of the LCAC circuit breaker panel. There will be no further device simulation.

2. Simulation of the entire main circuit breaker panel will be included in the PTT1-A. This panel will include:

    a. AC Circuits
        (1) Starboard Forward Primary AC Bus
        (2) Secondary AC Bus
    b. DC Emergency Bus Circuits
    c. DC Secondary Bus Circuits
    d. DC Primary Bus Circuits

3. The PTT1-A will not possess any display information readout features.

4. No device special effects will be simulated or incorporated in the PTT1-A.

5. System failures/malfunctions will not be simulated in the PTT1-A.

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Estimated availability of the device will be 8 hours/day, 5 days/week, and 52 weeks/year. Utilization of the device will be established following syllabus development.

B. The life expectancy of the device, based upon the training requirements, will depend on the number and types of LCAC changes. However, with this device, no change/modification will result in high cost.

C. The PTT1-A will allow for only one exercise. That exercise is the practice of circuit breaker check procedures.

FUNCTIONAL DESCRIPTION
FOR
LCAC PART-TASK TRAINER 1-B

I. PURPOSE OF THE DEVICE

A. The LCAC Part-Task Trainer 1-B (PTT1-B) will be utilized to train LCAC operators/engineers to perform fuel management panel checks. The PTT1-B will be employed to train operators/engineers in accomplishing four objectives. The following functional description is based on JEFF(B) data/information and may require modification at such time as the LCAC design freeze becomes effective.

B. The PTT1-B will have the capability of familiarizing the LCAC operator/engineer with the components of the fuel management panel. Further, it will provide the engineer an opportunity to practice fuel management panel check procedures.

C. The PTT1-B will be employed as a refresher training device for LCAC operators and engineers prior to their reassignment to a unit. It will also assist in proficiency maintenance of current LCAC operators and engineers.

II. TRAINING OBJECTIVES

A. Analysis results indicate that only four behaviors can be trained in the PTT1-B to the level of mastery required of LCAC operators and engineers. The PTT1-B training will provide:

1. Operators/engineers with fuel management panel check procedure familiarity, and

2. A means for assessing operator/engineer level of performance on the fuel management panel checks.

B. Training objectives for the PTT1-B are as follows:

1. Reinforce trainee knowledge related to identification and location of the fuel management panel and its components.

2. Provide trainee with the knowledge required to effectively monitor and perform fuel management panel check procedures.

C. Specific tasks/subtasks to be trained through utilization of the PTT1-B include:

7.1	Supervise unload
10.3.1	Perform underway refueling
10.3.2	Reload craft (at anchor)
13.3.6	Perform fuel system (main engines) emergency procedures

III. DEVICE CHARACTERISTICS

A. Characteristics of Device

The PTT1-B will be a pictorial representation of the LCAC fuel management panel located on the port side of the LCAC control station. It will present the fuel management panel, but not panel location relative to the entire control station. The PTT1-B will not be capable of simulating any other tasks, nor will it simulate any degraded modes or environmental conditions.

B. Requirements of the Device

The PTT1-B will be composed of one trainee station. Training procedures will include skills and techniques required to familiarize the trainee with the scan patterns and monitoring the fuel management panel during three phases of operation. These phases include:

1. At Beach
2. Reconfigure
3. Emergency/Abnormal Conditions Procedures

The PTT1-B will not have the capability (nor the requirement) of simulating any environmental/tactical variables or situations.

C. Performance Parameters

The PTT1-B will not possess any automation in regard to trainee performance measurement. Student performance measurements will be accomplished via instructor observation. Estimated performance requirements will be made following media selection and syllabus development. Specific requirements will be established after lesson specifications have been defined and completed.

D. Instructor Station

There is no requirement for a PTT1-B instructor station. Instructors will not be required to manipulate either device performance characteristics or environmental conditions, nor will such manipulations be possible.

E. Trainee Station

1. The trainee station will be a pictorial representation of the LCAC fuel management panel. There will be no further device simulation.

2. The PTT1-B will simulate the entire fuel management panel. Switches and indicators that shall be included are as follows:

    a. MAIN TANK VALVE switches
    b. LOW PRESS lights (port side)
    c. Port PRIMARY/STANDBY switch
    d. AUTO/MAN RESET switch
    e. Starboard PRIMARY/STANDBY switch
    f. LOW PRESS lights (starboard side)
    g. FUNCTION SELECTION rotary switch

        (1) NORM
        (2) CROSS FL BYP

(3) DEFUEL P

(4) DEFUEL S

(5) DEFUEL P-S

(6) OFF

(7) S-P TRANS

(8) P-S TRANS

(9) GRAVITY

(10) CROSS FLOW CLOSED

h. SEQUENCE switch (port side)

i. VALVE OPERATE switch

j. SEQUENCE switch (starboard side)

3. The PTT1-B will not possess any display information readout features.

4. No device special effects will be simulated or incorporated in the PTT1-B.

5. System failures/malfunctions will not be simulated in the PTT1-B.

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Estimated availability of the device will be 8 hours/day, 5 days/week, and 52 weeks/year. Utilization of the device will be established following syllabus development.

B. The life expectancy of the device, based upon the training requirements, will depend on the number and types of LCAC changes. However, with this device, no change/modification will result in high cost.

C. The PTT1-B will allow for only a number of exercises. These exercises will be identified following syllabus development and completion of lesson specification.

FUNCTIONAL DESCRIPTION

FOR

LCAC COCKPIT PROCEDURES TRAINER

I. PURPOSE OF THE DEVICE

A. The LCAC Cockpit Procedures Trainer (CPT) will be utilized to train LCAC operators and engineers in the normal and emergency/abnormal procedures required to effectively and safely operate the LCAC. The CPT will be employed to train operators/engineers in accomplishing 103 objectives in part or entirety. The following functional description is based on JEFF(B) data/information and may require modification at such time as the LCAC design freeze becomes effective.

B. The capability of the CPT includes facilitating learning of various control, instrument, switch, and light cockpit locations. Further, the CPT will familiarize the operator/engineer with normal and abnormal/emergency procedures that will be required for proficient LCAC operation. All switches, knobs, levers, rudder pedals, and control yoke will be present in the configuration. Craft instruments and indicators will respond to operator control inputs.

C. The CPT will be employed as a refresher training device for LCAC operators/engineers prior to their reassignment to a unit. It will also assist in proficiency maintenance of current LCAC operators/engineers.

II. TRAINING OBJECTIVES

A. Analysis results show that 422 out of 946 individual behaviors can be trained in the CPT to the level of mastery required of LCAC operators/engineers. An additional 421 behaviors may be practiced at the procedures level. Further, CPT utilization will result in the following training benefits:

1. Provides the operator/engineer the opportunity for indepth study of cockpit instruments, development of required procedural and psychomotor skills, and effective scan patterns/techniques in the context of a static external environment.

2. Allows for assessment of operator/engineer level of mastery related to the correct procedure selection and procedure step sequencing.

3. Allows for assessment of operator/engineer level of performance on procedural/non-procedural tasks requiring psychomotor control prior to training in the actual craft.

B. Training objectives for the LCAC CPT are as follows:

1. Reinforce trainee knowledge related to the characteristics, capabilities, and limitations of the LCAC operating systems.

2. Reinforce basic "in craft" pre-mission, underway, and post-mission procedures for both normal and emergency/abnormal conditions.

3. Provide trainee with knowledge required to effectively locate, identify, and state function of cockpit controls, instruments, switches, and lights.

4. Provide trainee with the knowledge and skills required to perform operations and maintain craft control in a static environment, that is, without the benefit of external visual or motion cues.

5. Provide the trainee with the skills and techniques required to perform all types of land/water mission and training operations within the constraint of reduced realism resulting from lack of external visual and motion cues/feedback.

C. Specific tasks/subtasks trained through utilization of the LCAC CPT are listed below.

3.1	Perform Pre-mission Checklist Procedures
3.1.53	Direct Operating Crew Station Manning
3.2	Start Craft
3.2.1	Perform Power-off Checklist Procedures*
3.2.2	Perform APU Start Checklist Procedures
3.2.3	Perform Pre-start Checklist Procedures
3.2.4	Perform Main Engine(s) Start Checklist Procedures
3.3	Perform Pre-Underway Checklist Procedures
3.4	Perform Lift-off and Hover Checklist Procedures
4.1	Transit from Land to Water
4.1.1	Obtain Clearance as Required
4.1.2	Maneuver to Outbound Heading
4.1.3	Perform Land to Water Transition
4.1.3.1	Perform Ramp or Slipway to Smooth Water Transition
4.1.3.2	Perform Beach to Smooth Water Transition
4.1.3.3	Perform Beach to Surf Transition
4.2	Exit Wet/Dry Well (Self-Propelled)
4.2.1	Exit Wet Well (Self-Propelled)
4.2.2	Exit Dry Well (Self-Propelled)
4.3	Perform Station-Keeping
4.3.1	Perform Single Station-Keeping
4.3.2	Perform Formation Station-Keeping
4.4	Disengage from Ship
5.1	Perform Transition Over Hump

*denotes full proficiency

5.2	Change Course
5.2.1	Change Course Upwind
5.2.2	Change Course Downwind
5.2.3	Change Course Crosswind
5.3	Hold Craft on Track
5.5	Perform Mission-Dependent Tasks
5.6	Perform Underway Main Engine Water Wash
5.7	Perform Normal Stopping (Over Water)
5.8	Come Off-Cushion (Over Water)
5.9	Operate in Boating Mode
5.10	Come On-Cushion (Over Water)
6.1	Transit Water to Land
6.1.1	Perform Smooth Water Approach
6.1.2	Perform Surf Approach
6.2	Fly Up a Slope
6.3	Fly Across a Slope
6.4	Hold Craft on Track in Yaw Moment
6.5	Cross Obstacles
6.6	Perform Normal Stopping (Over Land)
6.7	Come Off-Cushion (Over Land)
6.7.1	Come Off-Cushion Level
6.7.2	Come Off-Cushion On Slope
7.1	Supervise Unload
7.2	Perform Lift-off and Hover Checklist Procedures
8.1	Transit From Land to Water
8.1.1	Obtain Clearance as Required
8.1.2	Maneuver Craft to Outbound Heading

8.1.3	Perform Land to Water Transition
8.1.3.1	Perform Beach to Smooth Water Transition
8.1.3.2	Perform Beach to Surf Transition
9.1	Perform Transition Over Hump
9.2	Change Course
9.2.1	Change Course Upwind
9.2.2	Change Course Downwind
9.2.3	Change Course Crosswind
9.3	Hold Craft on Track
9.5	Perform Mission-Dependent Tasks
9.6	Perform Underway Main Engine Water Wash
9.7	Perform Normal Stopping (Over Water)
9.8	Come Off-Cushion (Over Water)
9.9	Operate in Boating Mode
9.10	Come On-Cushion (Over Water)
10.1	Fly Up To Moving Ship
10.2	Moor To Ship
10.2.1	Moor To Ship Underway
10.2.2	Moor To Ship at Anchor (or Pier)
10.3	Refuel/Reload Craft
10.3.1	Perform Underway Refueling
10.3.2	Reload Craft (at Anchor)
10.4	Enter Well Deck (Self-Propelled)
10.5	Transit Water to Land
10.5.1	Perform Smooth Water Approach
10.5.2	Perform Surf Approach
11.1	Come Off-Cushion (Over Land)

11.2	Perform Craft Securing Checklist Procedures
11.2.1	Perform Equipment Shutdown Procedures
11.2.2	Perform Engine Shutdown Procedures
11.2.3	Perform APU Shutdown Procedures
11.3	Perform Refueling
11.4	Perform Mission Log Completion*
13.1	Perform Emergency Stopping
13.1.1	Perform Emergency Stopping Over Land
13.1.2	Perform Emergency Stopping Over Water
13.2	Perform Fire Emergency Procedures
13.2.1	Perform Engine Fire Emergency Procedures
13.2.2	Perform APU Fire Emergency Procedures
13.2.3	Perform Craft Fire Emergency Procedures
13.2.4	Perform Deck/Cargo Fire Emergency Procedures
13.3	Recognize and React to Propulsion Power Loss Emergencies
13.3.1	Perform Single Engine Failure Emergency Procedures
13.3.2	Perform Multiple Engine Failure Emergency Procedures
13.3.3	Perform Transmission Failure Emergency Procedures
13.3.4	Perform N2 Govern Failure Emergency Procedures
13.3.5	Perform Fueling Failure Emergency Procedures
13.3.6	Perform Fuel System (Main Engines) Emergency Procedures
13.3.7	Perform Fuel System (APU) Emergency Procedures
13.4	Recognize and React to Lift System Failure Emerg. Procedures
13.4.1	Perform Cushion Failure Emergency Procedures
13.4.2	Perform Keel/Lateral Stability Bags Loss Emerg. Procedures
13.4.3	Perform Loss of Lift Fan Emergency Procedures

*denotes full proficiency

13.5 Recognize and React to Degradation of Craft Control

13.5.1 Perform Control System Failure Emergency Procedures

13.5.2 Perform Propeller Failure Emergency Procedures

13.5.3 Perform Rudder Actuator Failure Emergency Procedures

13.5.4 Perform Bow Thruster Failure Emergency Procedures

13.5.5 Perform APU Failure Emergency Procedures

13.5.6 Perform Generator Failure Emergency Procedures

13.6 Perform Miscellaneous Emergency Procedures

13.6.1 Perform Flooding Emergency Procedures

13.6.2 Perform Man-Overboard Emergency Procedures

13.6.3 Perform Collision Emergency Procedures

13.6.6 Perform Plow-in Recovery

13.7 Perform Miscellaneous Abnormal Procedures

13.7.2 *Perform Towing Operations*

13.7.2.1 Perform Pre-Towing Checklist Procedures

13.7.2.2 Perform Towing Over Water

13.7.2.3 Perform Towing Over Land

13.7.3 Perform APU Protective Shutdown Procedures

13.7.4 Perform Main Engine Start Sequence Failure Procedures

14.1 Perform Buoy Operations

14.1.1 Perform Buoy Approach

14.1.2 Depart Buoy

14.1.3 Translate Side-to-Side Using Buoy as Reference

III. DEVICE CHARACTERISTICS

A. Characteristics of Device

The CPT will be a replication of the LCAC cockpit and systems. It will contain all controls and instruments located in the operator/ engineer crew positions. The CPT will possess the capability to simulate all major tasks related to operator and engineer crew members for a given craft/mission combination. However, it will not have the capability of simulating environmental conditions which result in the generation of visual and vehicle motion cues.

B. Requirements of the Device

The CPT will contain one trainee station. Although environmental conditions will not be simulated, a separate instructor station will still be employed for use in manipulating various conditions, other than environmental. Training procedures will include all skills and techniques required to familiarize the trainee with cockpit layout and the various procedural tasks of the following phases of operation:

1. Pre-launch
2. Depart
3. Transit Water (loaded)
4. Transit Beach
5. At Beach
6. Depart Beach
7. Transit Water (unloaded)
8. Reconfigure
9. Post-mission
10. Perform Emergency and Abnormal Conditions Procedures
11. Training Specific Tasks

The CPT will not have the capability (nor the requirement) of simulating any environmental/tactical variables or situations.

C. Performance Parameters

The CPT will be capable of training 103 various operational tasks/subtasks. These tasks range from performing pre-mission checklist procedures to performing towing operations, of which many include complex/critical procedures. The CPT will not provide performance parameters associated with the use of LCAC sensors. Nor will it simulate interaction with other types of crafts, with the exception of communication via instructor role playing. However, critical tasks/procedures requiring operator/engineer interaction can be rehearsed to various proficiency levels with the absence of motion and external visual cues/feedback.

D. Performance Capabilities

The CPT will possess some degree of automation in regard to trainee performance measurement. In addition, student performance can be scored via instructor observation. Student performance measurements will include, but not be limited to, the following:

1. System identification and allocation of controls, switches, instruments, and lights.

2. Operator/engineer interaction requiring simultaneous/sequential control inputs.

3. Operator/engineer control response and input accuracy.

4. Operator response to instrument readings and various system/subsystem failures or malfunctions.

5. Practice of procedures to be employed for various missions and tasks.

Student scoring and automatic performance gathering/recording tools will allow the instructor to critique trainee performance in a systematic fashion, and will result in evaluation/assessment of operator/engineer proficiency for the various procedures and tasks being

trained. Estimated performance requirements will be made following media selection and syllabus development. Specific requirements will be established after lesson specifications have been defined and completed.

E. Instructor Station

1. The instructor station will not only contain all equipment necessary for student observation and performance measurement, but will also include all controls needed to initiate the various mission modes/phases, initial craft performance levels, and other trainer control inputs. In addition, the instructor station will be capable of inserting malfunctions/degraded modes of operation, monitoring/recording trainee action, and providing assistance to the instructor in his evaluation of trainee performance.

2. To eliminate unnecessary duplication, the instructor station will be located within the view of the student operator and engineer control stations. This will allow the instructor to monitor all cockpit instruments, controls, and indicators. This design will provide an overview of, and direct interaction with, trainee activities. Communications between instructor and trainee will be voice only through use of intercom.

3. The instructor station will be equipped with a keyboard console to allow instructor input of both gradual and abrupt degrades, malfunctions, or failures for appropriate LCAC systems/ subsystems.

F. Trainee Station

1. The trainee station will be a replica of the LCAC control station cockpit. Device simulation will provide for duplication of all controls, instruments, switches, and lights in order to ensure device consistency with the actual craft and to familiarize the trainee with their locations. All switches,

knobs, levers, gages, the control yoke, and rudder pedals are present in configuration and allow for actuation by, or response to, operator/engineer inputs.

2. Simulation of the entire LCAC control station cockpit will be included in the trainee stations. Sections of the cockpit, their associated panels, displays, and indicators include:

a. Port side

(1) Ramp Control Panel

(a) STERN UP/OFF/DN switch
(b) STERN CLOSED light
(c) BOW CLOSED light
(d) BOW UP/OFF/DN switch

(2) Fuel Condition Panel

(a) MAIN VALVE OPEN/CLOSE switch
(b) OVERFILL light
(c) PRESSURE IN NOZZLE light
(d) PRESSURE IN MANIFOLD light
(e) FLOW INTO STRIPPING TANK-PORT light
(f) FLOW INTO STRIPPING TANK-STBD light
(g) PORT FILL light
(h) STBD FILL light
(i) TANK VALVES OPEN/CLOSE switches
(j) DRAIN VALVE - PORT MAIN switch
(k) Port Main DIRT light
(l) Port Main WATER IN FUEL light
(m) DRAIN VALVE - PORT APU switch
(n) Port APU DIRT light
(o) Port APU WATER IN FUEL light
(p) DRAIN VALVE - STBD MAIN switch
(q) Stbd Main DIRT light
(r) Stbd Main WATER IN FUEL light
(s) DRAIN VALVE - STBD APU switch
(t) Stbd APU DIRT light
(u) Stbd APU WATER IN FUEL light
(v) FUEL FILTER CONDN lights
(w) ENG OIL FILTER CONDN lights

(3) Console

(a) INST. button
(b) LTS. button
(c) HF switch
(d) VHF switch
(e) VHF-M switch

(f) UHF switch
(g) HF/VHF switch
(h) ADF switch
(i) VOL knob
(j) Rotary Selector knob
(k) AC VOLTS meter
(l) VOLTS PRI/SEC switches
(m) GEN LOAD meter
(n) GEN ON-OFF/RESET-TEST switch
(o) AUTO DROPOUT ORIDE/NORM switch
(p) GROUND FAULT meter
(q) EXT POWER switch
(r) DC VOLTS meter
(s) DC AMPS meter
(t) AUTO DROPOUT ORIDE/NORM switch
(u) MAIN TANK VALVE switches
(v) LOW PRESS lights (port side)
(w) Port PRIMARY/STANDBY switch
(x) AUTO/MAN RESET switch
(y) Starboard PRIMARY/STANDBY switch
(z) LOW PRESS lights (starboard side)
(aa) FUNCTION SELECTION rotary switch
(bb) SEQUENCE switch (port side)
(cc) VALVE OPERATE switch
(dd) SEQUENCE switch (starboard side)
(ee) INSTRUMENT rotary switch
(ff) NAV switch
(gg) ANCHOR switch
(hh) BCN switch
(ii) CARGO switch
(jj) ON/OFF/STOW switch
(kk) SEARCHLIGHT EXTEND/RETRACT switch
(ll) AUDIO ON/OFF switch

(4) Main Instrument Panel

(a) LUBRICATION OIL STATUS panel
(b) OIL TEMP DEGREES F. indicator
(c) OIL PRESS PSIG indicator
(d) RADIO MAGNETIC indicator
(e) SPEED KNOTS indicator
(f) MASTER CAUTION light
(g) MASTER FIRE light
(h) FUEL QTY indicators
(i) FUEL MAN F, PRESS indicators
(j) APU ENGINE PERCENT RPM indicators
(k) APU EGT DEGREES F indicators
(l) NO. 1 APU CRANK/OFF switch
(m) NO. 1 APU START/STOP/RUN switch
(n) NO. 1 APU T/R PWR - BAT PWR switch
(o) NO. 2 APU CRANK/OFF switch
(p) NO. 2 APU START/STOP/RUN switch
(q) NO. 2 APU T/R PWR - BAT PWR switch
(r) ENGINE HEALTH MONITOR display units

b. Center Console

(1) Top Section

(a) BT switch
(b) R switch
(c) PROPS PORT switch
(d) PROPS STBD switch
(e) VERNIER PITCH switch
(f) OPER/STOW MODE switch
(g) FWD/REV MODE switch
(h) PORT gage
(i) STBD gage
(j) ENGINE MASTER switch
(k) Annunciator Panel
(l) DE-ICE switch
(m) WASH switch
(n) WIPER switch
(o) Wiper Control rotary switch
(p) DECK PWR OVED switch
(q) ZONE A TEST switch
(r) ZONE B TEST switch
(s) ZONE C TEST switch
(t) COUPLING R-BT switch
(u) COUPLING BT-R switch
(v) FRICTION wheel
(w) N_2 PORT ENGS lever
(x) N_2 STBD ENGS lever
(y) PORT PROP lever
(z) STBD PROP lever
(aa) FRICTION wheel

(2) Lower Section

(a) Fire Pull Handles
(b) Engine 2 PURGE/RESET switch
(c) Engine 2 START/STOP switch
(d) Engine 2 N_2 BRAKE switch
(e) Engine 4 PURGE/RESET switch
(f) Engine 4 START/STOP switch
(g) Engine 4 N_2 BRAKE switch
(h) Engine 3 PURGE/RESET switch
(i) Engine 3 START/STOP switch
(j) Engine 3 N_2 BRAKE switch
(k) Engine 1 PURGE/RESET switch
(l) Engine 1 START/STOP switch
(m) Engine 1 N_2 BRAKE switch
(n) FRICTION wheel
(o) ENG 2 throttle
(p) ENG 4 throttle
(q) ENG 3 throttle

(r) ENG 1 throttle
(s) FRICTION wheel
(t) ARM switch
(u) TEST RELAY 3 switch
(v) TEST RELAY 2 switch
(w) TEST RELAY 1 switch
(x) ALIGN TEST B button
(y) ALIGN TEST A button
(z) RESET button
(aa) B/T 2 light
(bb) B/T 1 light
(cc) RUDDER 2 and 4 lights
(dd) RUDDER 1 and 3 lights
(ee) PROP 2 light
(ff) PROP 1 light

c. Starboard Side

(1) Console

(a) LTS buttons
(b) HF SWITCH
(c) VHF switch
(d) VHF-M switch
(e) UHF switch
(f) HF/VHF switch
(g) ADF switch
(h) VOL knob
(i) Rotary Selector knob
(j) Gyro Synchronization indicator
(k) SLAVED/FREE SWITCH
(l) PUSH TO SET knob
(m) Thumbwheel Selector
(n) SELECTOR rotary switch
(o) PWR HI/LO switch
(p) SQUELCH knob
(q) MEGACYCLES knobs
(r) RCVR TEST button
(s) VHF-FM selector knob
(t) AUDIO knob
(u) 48.75.95 MHZ/30.47.95 MHZ FREQ BAND switch
(v) POWER OUTPUT HIGH/LOW switch
(w) THERMOSTAT knob
(x) THERMOSTAT OVERRIDE switch
(y) CONTROL BREAKER switch
(z) MAIN BREAKER switch
(aa) MASTER switch
(bb) SELECTOR switch
(cc) INSTR rotary transformer switch
(dd) CONSOLE 28V rotary switch
(ee) DOME RED ON/OFF switch
(ff) DOME WHITE ON/OFF switch
(gg) CONSOLE 115V rotary switch

(hh) RED ON/OFF button
(ii) WHITE ON/OFF button

(2) Main Instrument Panel

(a) AFT FUEL pull handle
(b) FWD FUEL pull handle
(c) LUBE OIL VALVES - PORT PROP OPEN/CLOSE switch
(d) LUBE OIL VALVES - PORT FWD OPEN/CLOSE switch
(e) LUBE OIL VALVES - PORT AFT OPEN/CLOSE switch
(f) LUBE OIL VALVES - STBD PROP OPEN/CLOSE switch
(g) LUBE OIL VALVES - STBD FWD OPEN/CLOSE switch
(h) LUBE OIL VALVES - STBD AFT OPEN/CLOSE switch
(i) STBD CLUTCH ENGAGE/DISENGAGE switch
(j) PROP PITCH indicator
(k) PORT CLUTCH ENGAGE/DISENGAGE switch
(l) WIND SPEED KNOTS indicator
(m) EGT, DEGREES, FX100 indicators
(n) N_2, PWR, % RPM indicators
(o) N_1 GG, % RPM indicators
(p) MASTER CAUTION light
(q) MASTER FIRE light
(r) RADIO MAGNETIC INDICATOR gage
(s) ELAPSED TIME clock
(t) SEA COND ROUGH/CALM switch
(u) PITCH indicator
(v) ROLL indicator
(w) RATE OF TURN DEG/SEC indicator
(x) Control Wheel
(y) MIC-INTERCOM switch
(z) TRIM REL switch
(aa) SPEED RADAR display

3. Although the cockpit features described above will be included in the CPT, along with dynamic display/instruments readouts, the trainer will remain static in regards to motion. That is, information will change with operator/engineer actuation/ manipulation of controls and other input devices, the only feedback that will be achieved will be through the changes in the display and instrument readouts. Feedback will not include the cues of motion or changing external visual scene.

4. No device special effects will be simulated or incorporated in the CPT.

5. System failures/malfunctions will be simulated in the CPT. This will allow the trainee to practice emergency/abnormal procedures as they would be performed during periods of actual system failure or malfunction. Specific failures and malfunctions to be simulated shall include the following emergency and abnormal operating procedures:

   a. Emergency stopping over land/water
   b. Engine fire emergency
   c. APU fire emergency
   d. Craft fire emergency
   e. Deck/cargo fire emergency
   f. Single engine failure
   g. Multiple engine failure
   h. Transmission failure
   i. N_2 Govern failure
   j. Fueling failure
   k. Fuel system (main engines) failure
   l. Fuel system (APU) failure
   m. Cushion failure
   n. Keel/lateral stability bags loss
   o. Loss of lift fan
   p. Control system failure
   g. Propeller failure
   h. Rudder actuator failure
   s. Bow Thruster failure
   t. APU failure
   u. Generator failure
   v. Flooding emergency
   w. Man-overboard emergency
   x. Collision emergency
   y. Plow-in recovery emergency
   z. Towing operations over land/water
   aa. APU protective shutdown failure
   bb. Main engine start sequence failure

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Estimated utilization of the CPT will be 8 hours/day, 5 days/week, and 52 weeks/year as required to meet the training specified in the curriculum. Instances requiring increased student throughout can be dealt with by increasing CPT utilization to 16 hours/day.

B. The life expectancy of the device, based upon the training requirements, will depend on the number and types of LCAC changes. Since the final LCAC design is still evolving, it is anticipated that many update changes will be required, particularly during the first year of CPT implementation.

C. Periods of unusually high and/or low device utilization will be identified following completion of the underway syllabus and lesson specifications.

D. Types of CPT exercises and time limits will be estimated and finalized after completion of lesson specification and underway syllabus definition.

FUNCTIONAL DESCRIPTION
FOR
LCAC COMPLEX PART TASK TRAINER

I. PURPOSE OF DEVICE

A. The LCAC complex part task trainer (PTT2) will be utilized to train LCAC operators/engineers in those unique skills and techniques involved in land/water craft operations. The PTT2 will be used to train operators and engineers in the partial completion of 70 objectives. Because design freeze on the LCAC has not been accomplished, this description is based on the JEFF(B) and will require update at the time of LCAC design freeze. It is intended to provide an order of magnitude of the detail and complexity of cockpit presentation.

B. The PTT2 will have the capability to train complex craft control, simulated amphibious assault operational mission and normal/emergency mode operations for LCAC craft systems under day/night and varying weather conditions.

C. It will also be utilized to provide refresher training for operators/engineers prior to being reassigned to a LCAC operational ACU unit and for instructor operators/engineers prior to duty in the LCAC training unit. In addition, it will be used to maintain the proficiency of operators and engineers current in the LCAC unit.

D. Further analysis will be necessary to determine if PTT2 should be installed on shipboard, providing additional training to maintain the proficiency of operators and engineers current in the LCAC unit.

II. TRAINING OBJECTIVES

A. Analysis disclosed that approximately 334 out of 946 behaviors can be accomplished in the PTT2 to the level of accomplishment required

for LCAC operators and engineers. A behavior can be defined as an operator activity required for the successful performance of a task/subtask. In addition, the PTT2 makes possible the measurement of an operator's/engineer's adaptability to craft operating tasks that may not be possible or practical in the operational craft because of resource and safety restrictions.

B. The training objectives for the PTT2 are as follows:

1. Reinforcement of trainee knowledge related to the characteristics, capabilities, and limitations of the LCAC operating systems.

2. Reinforcement of specific "in craft" pre-mission, underway and post mission procedures for both normal and emergency/abnormal conditions.

3. Provide the trainee with the skills and techniques required to perform specific types of land/water mission and training operations.

4. Provide the trainee with the knowledge and skills required to perform operations and maintain craft control under varying visibility, sea/land, and/or wind conditions.

C. Specifically, the LCAC PTT2 will be utilized to train operators and engineers in the performance of the following tasks/subtasks:

3.3 Perform Pre-Underway Checklist Procedures

3.4 Perform Lift-off and Hover Checklist Procedures

4.1 Transit from Land to Water

4.1.1 Perform Pre-Underway Checklist Procedures

4.1.2 Maneuver to Outbound Heading

4.1.3 Perform Land to Water Transition

4.1.3.1	Perform Ramp or Slipway to Smooth Water Transition
4.1.3.2	Perform Beach to Smooth Water Transition
4.1.3.3	Perform Beach to Surf Transition
4.2	Exit Wet/Dry Well (Self-Propelled)
4.2.1	Exit Wet Well (Self-Propelled)
4.2.2	Exit Dry Well (Self-Propelled)
4.3	Perform Station-Keeping
4.3.1	Perform Single Station-Keeping
4.3.2	Perform Formation Station-Keeping
4.4	Disengage from Ship
5.1	Perform Transition Over Hump
5.2	Change Course
5.2.1	Change Course Upwind
5.2.2	Change Course Downwind
5.2.3	Change Course Crosswind
5.3	Hold Craft on Track
5.4	Maintain Position in Formation Transit
5.5	Perform Mission-Dependent Tasks
5.7	Perform Normal Stopping (Over Water)
5.8	Come Off-Cushion (Over Water)
5.9	Operate in Boating Mode
5.10	Come On-Cushion (Over Water)
6.1	Transit Water to Land
6.1.1	Perform Smooth Water Approach
6.1.2	Perform Surf Approach
6.7	Come Off-Cushion (Over Land)
6.7.1	Come Off-Cushion Level

6.7.2	Come Off-Cushion On Slope
7.2	Perform Lift-off and Hover Checklist Procedures
8.1	Transit From Land to Water
8.1.1	Obtain Clearance as Required
8.1.2	Maneuver Craft to Outbound Heading
8.1.3	Perform Land to Water Transition
8.1.3.1	Perform Beach to Smooth Water Transition
8.1.3.2	Perform Beach to Surf Transition
9.1	Perform Transition Over Hump
9.2	Change Course
9.2.1	Change Course Upwind
9.2.2	Change Course Downwind
9.2.3	Change Course Crosswind
9.3	Hold Craft on Track
9.4	Maintain Position in Formation Transit
9.5	Perform Mission-Dependent Tasks
9.7	Perform Normal Stopping (Over Water)
9.8	Come Off-Cushion (Over Water)
9.9	Operate in Boating Mode
9.10	Come On-Cushion (Over Water)
10.4	Enter Well Deck (Self-Propelled)
10.5	Transit Water to Land
10.5.1	Perform Smooth Water Approach
10.5.2	Perform Surf Approach
11.1	Come Off-Cushion (Over Land)
13.1	Perform Emergency Stopping
13.1.1	Perform Emergency Stopping Over Land

13.1.2 Perform Emergency Stopping Over Water

13.3 Recognize and React to Propulsion Power Loss Emergencies

13.3.1 Perform Single Engine Failure Emergency Procedures

13.3.2 Perform Multiple Engine Failure Emergency Procedures

13.3.3 Perform Transmission Failure Emergency Procedures

13.3.4 Perform N2 Govern Failure Emergency Procedures

13.4 Recognize and React to Lift System Failure Emerg. Procedures

13.4.1 Perform Cushion Failure Emergency Procedures

13.4.2 Perform Keel/Lateral Stability Bags Loss Emerg. Procedures

13.4.3 Perform Loss of Lift Fan Emergency Procedures

13.5 Recognize and React to Degradation of Craft Control

13.5.2 Perform Propeller Failure Emergency Procedures

13.5.3 Perform Rudder Actuator Failure Emergency Procedures

13.5.4 Perform Bow Thruster Failure Emergency Procedures

13.6 Perform Miscellaneous Emergency Procedures

13.6.1 Perform Flooding Emergency Procedures

13.6.2 Perform Man-Overboard Emergency Procedures

13.6.3 Perform Collision Emergency Procedures

13.6.6 Perform Plow-in Recovery

13.7 Perform Miscellaneous Abnormal Procedures

13.7.2 Perform Towing Operations

13.7.2.1 Perform Pre-Towing Checklist Procedures

13.7.2.2 Perform Towing Over Water

13.7.2.3 Perform Towing Over Land

14.1 Perform Buoy Operations

14.1.1 Perform Buoy Approach

14.1.2 Depart Buoy

14.1.3 Translate Side-to-Side Using Buoy as Reference

III. DEVICE DESCRIPTION

A. Overview

The PTT2 shall replicate only the areas of the LCAC control station containing the primary controls which includes the control yoke, rudder pedals, prop pitch controls and vernier pitch, and the secondary controls which include the N_1, N_2, bow thruster flow and cushion air flow controls. In addition the PTT2 shall contain only those instruments, switches, knobs and displays necessary for operating and monitoring the primary and secondary controls.

B. Characteristics

1. The PTT2 shall contain one trainee station and one instructor operator station(IOS). Training procedures shall include all skills and techniques required to perform craft control in specific tasks included in the following training phases of operation:

   a. Pre-launch
   b. Depart
   c. Transit Water (loaded)
   d. Transit Beach
   e. At Beach
   f. Depart Beach
   g. Transit Water (unloaded)
   h. Reconfigure
   i. Post-Mission
   j. Emergency/Abnormal Conditions Procedures
   k. Training Specific Tasks

2. Environmental variables to be simulated shall include, but not be limited to, fog, rain, sea states, wind, sand, land/water surfaces.

3. The PTT2 shall simulate a tactical environment which will include the simultaneous distribution of hostile threats under

varying weather, sea and land conditions. These threats shall include TBD enemy aircraft, TBD enemy and friendly surface ships and TBD shore installations. Target systems/sites to be simulated are TBD based on defined operational mission definition and planned areas of potential use.

C. Performance Parameters

1. The PTT2 will simulate TBD number of operational and craft training situations. Maximum range for training situations will be from host ship 24 miles offshore to landing site. Areas of training criticality include the complex control of the craft in varying wind and land/sea conditions. More specifically, these complex craft control concepts include surf transit, plow-in conditions, and normal stopping. In addition, team coordinating (operator/engineer) and operations involving reduced visibility (i.e., night, fog) are critical training areas.

2. The PTT2 will have the capability of simulating craft conditions to the following limitations:

   a. Maximum gross weight -- 355,000 pounds
   b. Maximum craft speed -- 70 knots over water, 50 knots over land
   c. Maximum wind speed -- 25 knots (headwind)
   d. Maximum side slip (*drift) angle -- 90°
   e. Maximum wave height -- 12 feet
   f. Maximum Sea State -- 5
   g. Water depth effects from 0-20 feet
   h. Ambient water temperature effects from -40° -- 110°F
   i. Support ship limits (facing well deck only)
      (1) wind up to 25 knots
      (2) speed 10 knots (dry well operations)
      (3) ship motions-Trim ±15°, pitching ±15°, list ±15°, rolling ±35°
   j. Craft Center of Gravity (CG) at 355,000 pounds
      *1. Longitudinal - Hull station 479 to station 506
      *2. Lateral - 12.0 inches each side of craft longitudinal center line
      3. Vertical - Maximum 86.5 inches above waterline 0

   *based on hullborne damage stability criteria

k. Craft controls
   1. Rudder - ±30° travel at rate of 25°/sec.
   2. Propeller - ±40°, -30° travel at rate of 30°/sec.
   3. Bowthruster - forward mode 165° at rate of 50°/sec.
                  - reverse mode 165° at rate of 50°/sec.
   4. Vernier Pitch - ±15° of center of yoke relative to propeller pitch setting

D. Performance Capabilities

Craft performance capabilities cannot be identified until LCAC design freeze, at which time a definite task listing, media selection and syllabus will be developed. From the syllabus, preliminary simulator performance capabilities regarding degree of automation, student scoring, critique, debriefing and evaluation will be defined. Lesson specifications will then be developed from the syllabus. At the completion of the lesson specifications, specific simulator performance capabilities will be finalized.

E. Instructor Station

1. The instructor station shall be capable of complete trainer control to include the following:

   a. Implementing the Mission
   b. Inserting malfunctions/degrades
   c. Monitoring/Recording Trainee Actions
   d. Evaluating Trainee Performance

2. There shall be an adequately sized CRT displays capable of displaying the following information to the instructor:

   a. Indicators, repeaters or other means of conveying information pertaining to cockpit switch positions and display reading.

   b. An effectiveness display for monitoring emergency procedures.

3. Trainer controls at the operators station shall be capable of performing the following:

   a. Automatic exercise setup/initiation to a set of given under-way conditions.

   b. Performance parameter recording.

   c. Automatic maneuver playback.

   d. A method for inserting gradual or abrupt degrades, malfunctions or memergencies for all craft systems.

   e. A method for freeze and release of systems at any time.

   f. An automatic collision alarm with override control.

   g. Environmental controls to include:

      (1) 360° wind control with velocity from 0-25 knots (headwind)
      (2) Sea States 1-5
      (3) Daylight - night
      (4) Craft gross weight
      (5) Tactical environment

   h. Communication control to include:

      (1) Intercom between instructor and operator/engineer
      (2) Voice tape recorder synchronized with the mission evolution.

F. Trainee Station

1. The trainee station shall be a partial replica of the LCAC control station for the operator and engineer crew positions. Device simulation shall provide for the duplication and interaction of all primary and secondary controls, and all those instruments, switches, knobs and displays necessary for operating and monitoring the primary and secondary controls. The PTT2 will familiarize trainees with those behaviors required to perform craft maneuvers and respond to emergencies. Student activation of the controls and instrument displays shall duplicate the response of the LCAC.

2. Partial simulation of three sections of LCAC control station for the operator and engineer positions shall be included in the trainee station. Cockpit sections, their associated panels, displays, indicators and switches listed below are the JEFF(B) craft and will be changed as required upon design freeze of the LCAC cockpit. However, even though locations may change along with nomenclatures and types of displays, indicators and switches, an order of magnitude of the simulation problem can be gained.

a. Port side

(1) Console

(a) VOL knob

(2) Main Instrument Panel

(a) SPEED KNOTS indicator
(b) MASTER CAUTION light
(c) FUEL QTY indicators
(d) APU ENGINE PERCENT RPM indicators
(e) APU EGT DEGREES F indicators

b. Center Console

(1) Top Section

(a) BT switch
(b) R switch
(c) PROPS PORT switch
(d) PROPS STBD switch
(e) VERNIER PITCH switch
(f) OPER/STOW MODE switch
(g) FWD/REV MODE switch
(h) COUPLING R-BT switch
(i) COUPLING BT-R switch
(j) FRICTION wheel
(k) N_2 PORT ENGS lever
(l) N_2 STBD ENGS lever
(m) PORT PROP lever
(n) STBD PROP lever
(o) FRICTION wheel

(2) Lower Section

(a) ENG 2 throttle
(b) ENG 4 throttle
(c) ENG 3 throttle

(d) ENG 1 throttle
(e) FRICTION wheel

c. Starboard Side

(1) Main Instrument Panel

(a) PROP PITCH indicator
(b) WIND SPEED KNOTS indicator
(c) EGT, DEGREES, FX100 indicators
(d) N_2, PWR, % RPM indicators
(e) N_1 GG, % RPM indicators
(f) MASTER CAUTION light
(g) MASTER FIRE light
(h) RADIO MAGNETIC INDICATOR gage
(i) ELAPSED TIME clock
(j) PITCH indicator
(k) ROLL indicator
(l) RATE OF TURN DEG/SEC indicator
(m) Control Wheel
(n) MIC-INTERCOM switch
(o) TRIM REL switch
(p) SPEED RADAR display

3. The accuracy of read-out information in response to operator inputs shall be in accordance with the conditions and standards requirements of each task criterion objective.

4. Each task/subtask was analyzed by subject matter experts in terms of internal and external visual, audio and motion conditions present at the time of performance and whether the condition is a primary or secondary cue. Special simulation effects disclosed in the analysis were recorded on individual cue sheets for each task/subtask. The trainee station of the PTT2 shall simulate the following device special simulation effects as represented on the cue sheets:

a. Lighting

(1) Daylight
(2) Night

b. Visual System

(1) The visual system shall utilize Computer Generated Imagery in providing specific scenes necessary for achieving the following training capabilities:

(a) Over Terrain - land surface should include a flat terrain extending to the horizon.

(b) Beach - The beach scene is composed of surf, a smooth sloping beach and a flat terrain beyond the beach. The line of the crests of the breakers is parallel to the beach; the crests will have variable spacing.. In its simplest form the surf may be stylized to be only a flat, textured, moving surface. This scene will be viewed both in going from the ocean to land and returning.

(c) Ocean with Obstacles - The ocean would consist of long crested waves extending to infinity in all directions. The crests would be uniformly spaced and move at a constant velocity. In its simplest form the ocean may also be stylized to be only a flat textured surface that moves with respect to the stationary objects. The interaction of the waves with the ships' hull represents an aspect of the display problem of varying difficulty, depending upon the method used in the visual display. This is covered in the discussion of the visual display options in Appendix B. Also included in the ocean scene would be several sta- tionary box-like obstacles. These would represent objects the LCAC may have to avoid.

(d) Ocean with an LSD - Included as a part of the LSD should be an entrance well in the transom for the

LCAC. As with the supply ship it is free in azimuth, it can move with some velocity over the ocean surface and it may experience heave, pitch and roll motions which change the ship's attitude noticeably with respect to the ocean surface.

(e) The Visual Simulation of Fog - The option should be provided for making the visual scene contrast a function of the range along the line of sight. Ideally, this would be accomplished by summing an intensity signal proportional to range with the scene information.

(2) The visual scenes shall respond in real time to the craft conditions, controls and mission characteristics of the LCAC. The level of scene detail and resolution must be sufficient to provide the appropriate realism and cues during actual craft mission.

(3) The PTT2 shall contain individual visual screens for operator and engineer. Maximum field of view for each screen based on task assessment shall be ±24° horizontal port side, ±24° horizontal starboard side and ±18° vertical. Cost estimation for these specifications may suggest task assessment trade-off resulting in a increased FOV range.

5. Specific failures and malfunctions to be simulated shall include the following emergency and abnormal operating procedures:

a. Emergency stopping over land/water
b. Single engine failure
c. Multiple engine failure
d. Transmission failure
e. N_2 govern failure
f. Cushion failure
g. Keel/lateral stability bags failure
h. Lift fan failure
i. Propeller failure

j. Rudder actuator failure
k. Bow thruster failure
l. Flooding
m. Man overboard
n. Collision
o. Plow-in recovery
p. Towing over water/land

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Utilization of the PTT2 is estimated to be up to 16 hours/day, 5 days/week, and 52 weeks/year as required for training to meet the curriculum. Specific utilization will be defined upon completion of the Underway syllabus.

B. The PTT2 instructor to student ratio shall be one operator and one engineer per operator instructor.

C. The PTT2 shall have an operational service life of not less than 10 years or 48,000 hours under any of the operating and non-operating environments specified herein before major modernization is necessary. Operational service life is defined as the total operating time between the start of the operation and wear-out; where wear-out is defined as the point when overhaul or repair cost exceeds one-half of the replacement cost of the PTT2.

D. The control yoke and rudder pedals shall require special design attention because they are more heavily used than other instruments and controls.

E. Types of exercises and time limits required as well as high/low periods of device utilization will be specifically defined during development of the long-term LCAC operator training syllabus.

F. No system similar to the PTT2 is currently utilized; it will be the first ACV training device of any type.

V. RELIABILITY OF THE PTT2

The quantitative reliability requirements for the LCAC PTT2 are estimated to be:

A. mean-time-between-failures (MTBF) - 260 hours

B. minimum acceptable (MTBF) - 130 hours

VI. MAINTAINABILITY OF THE PTT2

The PTT2 shall be a modular design for ease of maintenance. The device shall have a design service life of at least ten years, and shall be designed to facilitate hardware and software modifications to reflect changes in the equipment installed on the operational LCAC vehicle. The quantitative maintainability design requirements for the PTT2 are estimated to be:

A. mean corrective maintenance downtime (M_{ct}) = 0.5 hour

B. maximum corrective maintenance downtime ($M_{max_{ct}}$) = 5.0 hour (90th percentile)

FUNCTIONAL DESCRIPTION
for
LCAC OPERATIONAL UNDERWAY TRAINER

I. PURPOSE OF DEVICE

A. The LCAC Operational Underway Trainer (OUT) will be utilized to train LCAC operators and engineers in those unique skills and techniques involved in land/water craft operations. The OUT will be used to train operators and engineers in accomplishing 106 objectives as presented in Appendix A. Because design freeze on the LCAC cockpit has not been accomplished, this description is based on the JEFF(B) and will require update at the time of LCAC cockpit design freeze. It is intended to provide an order of magnitude of the detail and complexity of cockpit presentation.

B. The OUT will have the capability to train basic craft control, simulated amphibious assault operational mission and normal/ emergency mode operations for LCAC craft systems under day/night and varying weather conditions.

C. It will also be utilized to provide refresher training for operators and engineers prior to being reassigned to an LCAC operational ACU and for instructor operators and engineers prior to duty in the LCAC training unit. In addition, it will be used to maintain the proficiency of operators and engineers current in the LCAC.

II. TRAINING OBJECTIVES

A. Analysis disclosed that approximately 843 out of 946 behaviors can be accomplished in the OUT to the level of accomplishment required for LCAC operators/engineers. A behavior is defined as an activity required for the successful performance of a task/ subtask. In addition, the OUT makes possible the measurement of an operator's/ engineer's adaptability to craft operating tasks that may not be

possible or practical in the operational craft because of resource and safety restrictions.

B. The training objectives for the OUT are as follows:

1. Reinforcement of trainee knowledge related to the characteristics, capabilities, and limitations of LCAC operating systems.

2. Reinforcement of all "in craft" pre-mission, underway and post mission procedures for both normal and emergency/abnormal conditions.

3. Provide the trainee with the skills and techniques required to perform all types of land/water mission and training operations.

4. Provide the trainee with the knowledge and skills required to perform operations and maintain craft control under varying visibility, sea/land, and/or wind conditions.

C. Specifically, the LCAC OUT will be utilized to train operators and engineers to full or partial mastery of performance of the following tasks/subtasks:

3.1	Perform Pre-mission Checklist Procedures
3.1.53	Direct Operating Crew Station Manning*
3.2	Start Craft
3.2.1	Perform Power-off Checklist Procedures*
3.2.2	Perform APU Start Checklist Procedures*
3.2.3	Perform Pre-start Checklist Procedures
3.2.4	Perform Main Engine(s) Start Checklist Procedures
3.3	Perform Pre-Underway Checklist Procedures

*denotes full proficiency

3.4	Perform Lift-off and Hover Checklist Procedures
4.1	Transit from Land to Water
4.1.1	Obtain Clearance as Required
4.1.2	Maneuver to Outbound Heading
4.1.3	Perform Land to Water Transition
4.1.3.1	Perform Ramp or Slipway to Smooth Water Transition
4.1.3.2	Perform Beach to Smooth Water Transition
4.1.3.3	Perform Beach to Surf Transition
4.2	Exit Wet/Dry Well (Self-Propelled)
4.2.1	Exit Wet Well (Self-Propelled)
4.2.2	Exit Dry Well (Self-Propelled)
4.3	Perform Station-Keeping
4.3.1	Perform Single Station-Keeping
4.3.2	Perform Formation Station-Keeping
4.4	Disengage from Ship
5.1	Perform Transition Over Hump
5.2	Change Course
5.2.1	Change Course Upwind
5.2.2	Change Course Downwind
5.2.3	Change Course Crosswind
5.3	Hold Craft on Track
5.4	Maintain Position in Formation Transit
5.5	Perform Mission-Dependent Tasks
5.6	Perform Underway Main Engine Water Wash
5.7	Perform Normal Stopping (Over Water)
5.8	Come Off-Cushion (Over Water)
5.9	Operate in Boating Mode

5.10	Come On-Cushion (Over Water)
6.1	Transit Water to Land
6.1.1	Perform Smooth Water Approach
6.1.2	Perform Surf Approach
6.2	Fly Up a Slope
6.3	Fly Across a Slope
6.4	Hold Craft on Track in Yaw Moment
6.5	Cross Obstacles
6.6	Perform Normal Stopping (Over Land)
6.7	Come Off-Cushion (Over Land)
6.7.1	Come Off-Cushion Level
6.7.2	Come Off-Cushion On Slope
7.1	Supervise Unload
7.2	Perform Lift-off and Hover Checklist Procedures
8.1	Transit From Land to Water
8.1.1	Obtain Clearance as Required
8.1.2	Maneuver Craft to Outbound Heading
8.1.3	Perform Land to Water Transition
8.1.3.1	Perform Beach to Smooth Water Transition
8.1.3.2	Perform Beach to Surf Transition
9.1	Perform Transition Over Hump
9.2	Change Course
9.2.1	Change Course Upwind
9.2.2	Change Course Downwind
9.2.3	Change Course Crosswind
9.3	Hold Craft on Track
9.4	Maintain Position in Formation Transit

9.5	Perform Mission-Dependent Tasks
9.6	Perform Underway Main Engine Water Wash
9.7	Perform Normal Stopping (Over Water)
9.8	Come Off-Cushion (Over Water)
9.9	Operate in Boating Mode
9.10	Come On-Cushion (Over Water)
10.1	Fly Up To Moving Ship
10.2	Moor To Ship
10.2.1	Moor To Ship Underway
10.2.2	Moor To Ship at Anchor (or Pier)
10.3	Refuel/Reload Craft
10.3.1	Perform Underway Refueling
10.3.2	Reload Craft (at Anchor)
10.4	Enter Well Deck (Self-Propelled)
10.5	Transit Water to Land
10.5.1	Perform Smooth Water Approach
10.5.2	Perform Surf Approach
11.1	Come Off-Cushion (Over Land)
11.2	Perform Craft Securing Checklist Procedures*
11.2.1	Perform Equipment Shutdown Procedures*
11.2.2	Perform Engine Shutdown Procedures*
11.2.3	Perform APU Shutdown Procedures*
11.3	Perform Refueling
11.4	Perform Mission Log Completion*
13.1	Perform Emergency Stopping
13.1.1	Perform Emergency Stopping Over Land

*denotes full proficiency

13.1.2 Perform Emergency Stopping Over Water

13.2 Perform Fire Emergency Procedures

13.2.1 Perform Engine Fire Emergency Procedures

13.2.2 Perform APU Fire Emergency Procedures

13.2.3 Perform Craft Fire Emergency Procedures

13.2.4 Perform Deck/Cargo Fire Emergency Procedures

13.3 Recognize and React to Propulsion Power Loss Emergencies

13.3.1 Perform Single Engine Failure Emergency Procedures

13.3.2 Perform Multiple Engine Failure Emergency Procedures

13.3.3 Perform Transmission Failure Emergency Procedures

13.3.4 Perform N2 Govern Failure Emergency Procedures

13.3.5 Perform Fueling Failure Emergency Procedures

13.3.6 Perform Fuel System (Main Engines) Emergency Procedures

13.3.7 Perform Fuel System (APU) Emergency Procedures

13.4 Recognize and React to Lift System Failure Emerg. Procedures

13.4.1 Perform Cushion Failure Emergency Procedures

13.4.2 Perform Keel/Lateral Stability Bags Loss Emerg. Procedures

13.4.3 Perform Loss of Lift Fan Emergency Procedures

13.5 Recognize and React to Degradation of Craft Control

13.5.1 Perform Control System Failure Emergency Procedures

13.5.2 Perform Propeller Failure Emergency Procedures

13.5.3 Perform Rudder Actuator Failure Emergency Procedures

13.5.4 Perform Bow Thruster Failure Emergency Procedures

13.5.5 Perform APU Failure Emergency Procedures

13.5.6 Perform Generator Failure Emergency Procedures

13.6 Perform Miscellaneous Emergency Procedures

13.6.1 Perform Flooding Emergency Procedures

13.6.2 Perform Man-Overboard Emergency Procedures

13.6.3 Perform Collision Emergency Procedures

13.6.6 Perform Plow-in Recovery

13.7 Perform Miscellaneous Abnormal Procedures

13.7.2 Perform Towing Operations

13.7.2.1 Perform Pre-Towing Checklist Procedures

13.7.2.2 Perform Towing Over Water

13.7.2.3 Perform Towing Over Land

13.7.3 Perform APU Protective Shutdown Procedures

13.7.4 Perform Main Engine Start Sequence Failure Procedures

14.1 Perform Buoy Operations

14.1.1 Perform Buoy Approach

14.1.2 Depart Buoy

14.1.3 Translate Side-to-Side Using Buoy as Reference

III. DEVICE DESCRIPTION

A. Overview

The OUT shall replicate the control station of the LCAC and its systems for the operator and engineer crew positions. It shall contain the capability to simulate all major tasks related to operator and engineer crew members for a given craft/ mission combination. It shall have the capability of simulating environmental conditions necessary for mission performance including, but not limited to, motion, visual and dynamic vehicle characteristics.

B. Characteristics

1. The OUT shall contain one trainee station with two positions and one instructor station with one position. Training procedures

shall include all skills and techniques requircd to perform the following training phases of operation:

a. Pre-launch
b. Depart
c. Transit Water (loaded)
d. Transit Beach
e. At Beach
f. Depart Beach
g. Transit Water (unloaded)
h. Reconfigure
i. Post-Mission
j. Emergency/Abnormal Conditions Procedures
k. Training Specific Tasks

2. Environmental variables to be simulated shall include, but not be limited to, fog, rain, sea states, wind, sand, and land/water surfaces.

3. The OUT shall simulate a tactical environment which will include the simulataneous distribution of hostile threats under varying weather, sea and land conditions. These threats shall include TBD enemy aircraft, TBD enemy and friendly surface ships and TBD shore installations. Target systems/sites to be simulated are TBD based on defined operational mission definition and planned areas of potential use.

C. Performance Parameters

1. The OUT will simulate TBD number of operational and craft training situations. Maximum range for training situations will be from host ship 24 miles offshore to landing site up to 1,000 yards inland. Areas of training criticality include the complex control of the craft in varying wind and land/sea conditions. More specifically, these complex craft control concepts include surf transit, plow-in conditions, and normal and emergency stopping. In addition, team coordinating (operator/engineer) operations involving reduced visibility (i.e., night, fog) as well as overall systems management are critical training areas.

2. The OUT will have the capability of simulating craft conditions to the following limitations:

   a. Maximum gross weight -- 355,000 pounds
   b. Maximum craft speed -- 70 knots over water, 50 knots over land
   c. Maximum wind speed -- 25 knots (headwind)
   d. Maximum sideslip (drift) angle -- 90°
   e. Maximum wave height -- 12 feet
   f. Maximum Sea State -- 5
   g. Water depth effects from 0-20 feet
   h. Ambient water temperature effects from -40°--110°F
   i. Vibration limits - not to exceed horizontal and vertical limits
   j. Support ship limits
      1. wind up to 25 knots
      2. speed 10 knots (dry well operations)
      3. ship motions-Trim ±15°, pitching ±15°, list ±15°, rolling ±35°
   k. Craft Center of Gravity (CG) at 355,000 pounds
      *1. Longitudinal - Hull station 479 to station 506
      *2. Lateral - 12.0 inches each side of craft longitudinal center line
      3. Vertical - Maximum 86.5 inches above waterline 0

      *based on hullborne damage stability criteria

   l. Craft controls
      1. Rudder - ±30° travel at rate of 25°/sec.
      2. Propeller - ±40°, -30° travel at rate of 20°/sec,
      3. Bow Thruster - forward mode 165° at rate of 50°/sec
         - reverse mode 165° at rate of 50°/sec.
      4. Vernier Pitch - ±15° of center of yoke relative to propeller pitch setting
   m. Other craft - up to and including two other ACVs.

D. Performance Capabilities

Craft performance capabilities cannot be identified until LCAC design freeze, at which time a definitive task listing, media selection and syllabus will be developed. From the syllabus, preliminary craft performance capabilities regarding degree of automation, student scoring, critique, debriefing and evaluation will be defined. Lesson specifications will then be developed from the syllabus. At the completion of the lesson specifications, specific simulator performance capabilities will be finalized.

E. Instructor Station

1. The instructor station shall be capable of complete trainer control to include the following:

    a. Implementing the Mission
    b. Inserting malfunctions/degrades
    c. Monitoring/Recording Trainee Actions
    d. Provide assistance to the instructor in his evaluation of trainee performance

2. There shall be an adequately sized CRT displays capable of displaying the following information to the instructor:

    a. Indicators, repeaters or other means of conveying information pertaining to cockpit switch positions and display readings.
    b. An effectiveness display for monitoring emergency procedures.

3. Trainer controls at the operators station shall be capable of performing the following:

    a. Automatic exercise setup/initiation to a set of given underway conditions.
    b. Performance parameter recording.
    c. Hard copy and/or digital plotter/printer printout of any set of selected underway parameters and display information.
    d. Automatic maneuver playback.
    e. A method for inserting gradual or abrupt degrades, malfunctions or emergencies for all craft systems.
    f. A method for freeze and release of systems at any time.
    g. An automatic collision alarm with override control.
    h. Environmental controls to include:

(1) 360° wind control with velocity from 0-25 knots
(2) Sea States 1-5
(3) Daylight - night
(4) Vibration limits
(5) Craft gross weight
(6) Tactical environment

i. Communication control to include:

(1) Intercom between instructor and operator/engineer
(2) Voice tape recorder synchronized with the mission evolution.
(3) Control of base/comm facilities.

F. Trainee Station

1. The trainee station shall be a replica of the LCAC control station cockpit for the operator and engineer crew positions. Device simulation shall provide for the duplication and interaction of all controls, instruments, communication and navigation systems and other equipment necessary to familiarize the trainees with those behaviors required to perform craft maneuvers, operate systems and respond to emergencies. Student activation of the controls and instrument displays shall duplicate the response of the LCAC.

2. Simulation of the entire LCAC control station cockpit for the operator and engineer positions shall be included in the trainee stations. Cockpit sections, their associated panels, displays, indicators and switches listed below are for the JEFF(B) craft and will be changed as required upon design freeze of the LCAC cockpit. However, even though locations may change along with nomenclatures and types of displays, indicators and switches, and order of magnitude of the simulation problem can be gained.

a. Port side

(1) Ramp Control Panel

(a) STERN UP/OFF/DN switch
(b) STERN CLOSED light
(c) BOW CLOSED light
(d) BOW UP/OFF/DN switch

(2) Fuel Condition Panel

(a) MAIN VALVE OPEN/CLOSE switch
(b) OVERFILL light
(c) PRESSURE IN NOZZLE light
(d) PRESSURE IN MANIFOLD light
(e) FLOW INTO STRIPPING TANK-PORT light
(f) FLOW INTO STRIPPING TANK-STBD light
(g) PORT FILL light
(h) STBD FILL light
(i) TANK VALVES OPEN/CLOSE switches
(j) DRAIN VALVE - PORT MAIN switch
(k) Port Main DIRT light
(l) Port Main WATER IN FUEL light
(m) DRAIN VALVE - PORT APU switch
(n) Port APU DIRT light
(o) Port APU WATER IN FUEL light
(p) DRAIN VALVE - STBD MAIN switch
(q) Stbd Main DIRT light
(r) Stbd Main WATER IN FUEL light
(s) DRAIN VALVE - STBD APU switch
(t) Stbd APU DIRT light
(u) Stbd APU WATER IN FUEL light
(v) FUEL FILTER CONDN lights
(w) ENG OIL FILTER CONDN lights

(3) Console

(a) INST. button
(b) LTS. button
(c) HF switch
(d) VHF switch
(e) VHF-M switch
(f) UHF switch
(g) HF/VHF switch
(h) ADF switch
(i) VOL knob
(j) Rotary Selector knob
(k) AC VOLTS meter
(l) VOLTS PRI/SEC switches
(m) GEN LOAD meter
(n) GEN ON-OFF/RESET-TEST switch
(o) AUTO DROPOUT ORIDE/NORM switch
(p) GROUND FAULT meter
(q) EXT POWER switch
(r) DC VOLTS meter
(s) DC AMPS meter
(t) AUTO DROPOUT ORIDE/NORM switch
(u) MAIN TANK VALVE switches
(v) LOW PRESS lights (port side)
(w) Port PRIMARY/STANDBY switch
(x) AUTO/MAN RESET switch
(y) Starboard PRIMARY/STANDBY switch

(z) LOW PRESS lights (starboard side)
(aa) FUNCTION SELECTION rotary switch
(bb) SEQUENCE switch (port side)
(cc) VALVE OPERATE switch
(dd) SEQUENCE switch (starboard side)
(ee) INSTRUMENT rotary switch
(ff) NAV switch
(gg) ANCHOR switch
(hh) BCN switch
(ii) CARGO switch
(jj) ON/OFF/STOW switch
(kk) SEARCHLIGHT EXTEND/RETRACT switch
(ll) AUDIO ON/OFF switch

(4) Main Instrument Panel

(a) LUBRICATION OIL STATUS panel
(b) OIL TEMP DEGREES F. indicator
(c) OIL PRESS PSIG indicator
(d) RADIO MAGNETIC indicator
(e) SPEED KNOTS indicator
(f) MASTER CAUTION light
(g) MASTER FIRE light
(h) FUEL QTY indicators
(i) FUEL MAN F, PRESS indicators
(j) APU ENGINE PERCENT RPM indicators
(k) APU EGT DEGREES F indicators
(l) NO. 1 APU CRANK/OFF switch
(m) NO. 1 APU START/STOP/RUN switch
(n) NO. 1 APU T/R PWR - BAT PWR switch
(o) NO. 2 APU CRANK/OFF switch
(p) NO. 2 APU START/STOP/RUN switch
(q) NO. 2 APU T/R PWR - BAT PWR switch
(r) ENGINE HEALTH MONITOR display units

b. Center Console

(1) Top Section

(a) BT switch
(b) R switch
(c) PROPS PORT switch
(d) PROPS STBD switch
(e) VERNIER PITCH switch
(f) OPER/STOW MODE switch
(g) FWD/REV MODE switch
(h) PORT gage
(i) STBD gage
(j) ENGINE MASTER switch
(k) Annunciator Panel
(l) DE-ICE switch (configured)
(m) WASH switch (configured)
(n) WIPER switch (configured)

(o) Wiper Control rotary switch (configured)
(p) DECK PWR OVED switch
(q) ZONE PWR OVED switch
(r) ZONE B TEST switch
(s) ZONE C TEST switch
(t) COUPLING R-BT switch
(u) COUPLING BT-R switch
(v) FRICTION wheel
(w) N_2 PORT ENGS lever
(x) N_2 STBD ENGS lever
(y) PORT PROP lever
(z) STBD PROP lever
(aa) FRICTION wheel

(2) Lower Section

(a) Fire Pull Handles
(b) Engine 2 PURGE/RESET switch
(c) Engine 2 START/STOP switch
(d) Engine 2 N_2 BRAKE switch
(e) Engine 4 PURGE/RESET switch
(f) Engine 4 START/STOP switch
(g) Engine 4 N_2 BRAKE switch
(h) Engine 3 PURGE/RESET switch
(i) Engine 3 START/STOP switch
(j) Engine 3 N_2 BRAKE switch
(k) Engine 1 PURGE/RESET switch
(l) Engine 1 START/STOP switch
(m) Engine 1 N_2 BRAKE switch
(n) FRICTION wheel
(o) ENG 2 throttle
(p) ENG 4 throttle
(q) ENG 3 throttle
(r) ENG 1 throttle
(s) FRICTION wheel
(t) ARM switch
(u) TEST RELAY 3 switch
(v) TEST RELAY 2 switch
(w) TEST RELAY 1 switch
(x) ALIGN TEST B button
(y) ALIGN TEST A button
(z) RESET button
(aa) B/T 2 light
(bb) B/T 1 light
(cc) RUDDER 2 and 4 lights
(dd) RUDDER 1 and 3 lights
(ee) PROP 2 light
(ff) PROP 1 light

c. Starboard Side

(1) Console

(a) LTS buttons
(b) HF SWITCH
(c) VHF switch
(d) VHF-M switch
(e) UHF switch
(f) HF/VHF switch
(g) ADF switch
(h) VOL knob
(i) Rotary Selector knob
(j) Gyro Synchronization indicator
(k) SLAVED/FREE SWITCH
(l) PUSH TO SET knob
(m) Thumbwheel Selector
(n) SELECTOR rotary switch
(o) PWR HI/LO switch
(p) SQUELCH knob
(q) MEGACYCLES knobs
(r) RCVR TEST button
(s) VHF-FM selector knob
(t) AUDIO knob
(u) 48.75.95 MHZ/30.47.95 MHZ FREQ BAND switch
(v) POWER OUTPUT HIGH/LOW switch
(w) THERMOSTAT knob (configured)
(x) THERMOSTAT OVERRIDE switch (configured)
(y) CONTROL BREAKER switch (configured)
(z) MAIN BREAKER switch (configured)
(aa) MASTER switch (configured)
(bb) SELECTOR switch (configured)
(cc) INSTR rotary transformer switch
(dd) CONSOLE 28V rotary switch
(ee) DOME RED ON/OFF switch
(ff) DOME WHITE ON/OFF switch
(gg) CONSOLE 115V rotary switch
(hh) RED ON/OFF button
(ii) WHITE ON/OFF button

(2) Main Instrument Panel

(a) AFT FUEL pull handle
(b) FWD FUEL pull handle
(c) LUBE OIL VALVES - PORT PROP OPEN/CLOSE switch
(d) LUBE OIL VALVES - PORT FWD OPEN/CLOSE switch
(e) LUBE OIL VALVES - PORT AFT OPEN/CLOSE switch
(f) LUBE OIL VALVES - STBD PROP OPEN/CLOSE switch
(g) LUBE OIL VALVES - STBD FWD OPEN/CLOSE switch
(h) LUBE OIL VALVES - STBD AFT OPEN/CLOSE switch
(i) STBD CLUTCH ENGAGE/DISENGAGE switch
(j) PROP PITCH indicator
(k) PORT CLUTCH ENGAGE/DISENGAGE switch
(l) WIND SPEED KNOTS indicator
(m) EGT, DEGREES, FX100 indicators
(n) N_2, PWR, % RPM indicators
(o) N_1 GG, % RPM indicators

(p) MASTER CAUTION light
(q) MASTER FIRE light
(r) RADIO MAGNETIC INDICATOR gage
(s) ELAPSED TIME clock
(t) SEA COND ROUGH/CALM switch
(u) PITCH indicator
(v) ROLL indicator
(w) RATE OF TURN DEG/SEC indicator
(x) Control Wheel
(y) MIC-INTERCOM switch
(z) TRIM REL switch
(aa) SPEED RADAR display

3. The accuracy of read-out information in response to operator inputs shall be in accordance with the conditions and standards requirements of each task criterion objective.

4. Each task/subtask was analyzed by subject matter experts in terms of internal and external visual, audio and motion conditions present at the time of performance and whether the condition is a primary or secondary cue. Special simulation effects disclosed in the analysis were recorded on individual cue sheets for each task/subtask. The trainee station of the OUT shall simulate the following device special simulation effects as represented on the cue sheets:

a. Sound

(1) Engine
(2) APU
(3) Transmission
(4) Propeller pitch
(5) Bow thruster
(6) Hull (on-cushion)
(7) Hull (off-cushion)
(8) Configuration changes
(9) Aural warning tones

b. Lighting

(1) Daylight
(2) Night

c. Motion

(1) The OUT will incorporate an external motion cueing system. Analysis disclosed that 46% of the total task/subtask listing require motion as a primary cue with the emphasis on roll, pitch and yaw. Combinations of these three degrees, as well as individual and combined requirements for heave, surge and sway, are also present and will enhance other task performance. Thus, a motion system with six degrees of freedom is recommended.

(2) The OUT will incorporate a control loading system to provide control yoke friction force and rudder pedal feel.

(3) The fidelity of motion system combinations shall be adequate to compliment visual cues.

d. Visual System

(1) The visual system shall utilize Computer Generated Imagery in providing specific scenes necessary for achieving the following training capabilities:

(a) Over Terrain - Terrain should include hills or slopes, ditches, obstacles such as houses, walls, step changes in elevation, and trees. Beyond these features a flat terrain extending to the horizon is desirable. These terrain features may be all located within an area 1 mile by 1 mile.

(b) Beach - The beach scene is composed of surf, a smooth sloping beach, trees or other TBD objects at the upper edge of the beach, and a flat terrain beyond the beach. The line of the crests of the breakers is parallel to the beach; the crests will

have variable spacing. In its simplest form the surf may be stylized to be only a flat, textured, moving surface. This scene will be viewed both in going from the ocean to land and returning.

(c) Ocean with Obstacles - The ocean would consist of long crested waves extending to infinity in all directions. The crests would be uniformly spaced and move at a constant velocity. In its simplest form the ocean may also be stylized to be only a flat textured surface that moves with respect to the stationary objects. The interaction of the waves with the ships' hulls represents an aspect of the display problem of varying difficulty, depending upon the method used in the visual display. This is covered in the discussion of the visual display options in Appendix B. Also included in the ocean scene would be several stationary box-like obstacles. These would represent objects the LCAC may have to avoid.

(d) Ocean with a Supply Ship - The supply ship may move at low velocity over the ocean surfacce at any heading relative to the LCAC and may be subjected to heave, pitch and roll motions; these motions will be apparent with respect to the ocean surface.

(e) Ocean with an LSD - Included as a part of the LSD should be an entrance well in the transom for the LCAC. As with the supply ship it is free in azimuth, it can move with some velocity over the ocean surface and it may experience heave, pitch and roll motions which change the ship's attitude noticeably with respect to the ocean surface. Of particular criticality is the well deck detail

during closure/separation in well deck entry/exit.

(f) The Visual Simulation of Fog - The option should be provided for making the visual scene contrast a function of the range along the line of sight. Ideally, this would be accomplished by summing an intensity signal proportional to range with the scene information.

(2) The visual scenes shall respond in real time to the craft conditions, controls and mission characteristics of the LCAC. The level of scene detail and resolution must be sufficient to provide the appropriate realism and cues during actual craft mission.

(3) Maximum field of view range for the OUT based on task assessment shall be 75° horizontal port side, 90° horizontal starboard side and ±20° vertical. Cost estimation for these specifications may suggest task assessment trade-off resulting in a reduced FOV range.

5. Specific failures and malfunctions to be simulated shall include the following emergency and abnormal operating procedures:

a. Emergency stopping over land/water
b. Engine fire emergency
c. APU fire emergency
d. Craft fire emergency
e. Deck/cargo fire emergency
f. Single engine failure
g. Multiple engine failure
h. Transmission failure
i. N_2 Govern failure
j. Fueling failure
k. Fuel system (main engines) failure
l. Fuel system (APU) failure
m. Cushion failure
n. Keel/lateral stability bags loss
o. Loss of lift fan
p. Control system failure

q. Propeller failure
r. Rudder actuator failure
s. Bow Thruster failure
t. APU failure
u. Generator failure
v. Flooding emergency
w. Man-overboard emergency
x. Collision emergency
y. Plow-in recovery emergency
z. Towing operations over land/water
aa. APU protective shutdown failure
bb. Main engine start sequence failure

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Utilization of the OUT in regards to hours/day, days/week, and weeks/year as required for training to meet the curriculum will be defined upon completion of the Underway syllabus. However, maximum utilization of the OUT is estimated as approaching 16 hours/day, 240 days/year at the time of full pipeline input by 1990.

B. The OUT instructor-to-student ratio shall be one operator and one engineer per operator instructor.

C. The OUT shall have an operational service life of not less than 10 years or 48,000 hours under any of the operating and non-operating environments specified herein before major modification is necessary. Operational service life is defined as the total operating time between the start of the operation and wear-out; where wear-out is defined as the point when overhaul or repair cost exceeds one-half of the replacement cost of the OUT.

D. The control yoke and rudder pedals shall require special design attention because they are more heavily used than other instruments and controls.

E. Types of exercises and time limits required as well as high/low periods of device utilization will be specifically defined during development of the long-term LCAC syllabus.

F. The OUT will be the first ACV training device of any type; therefore, no system similar to the OUT is currently utilized.

V. RELIABILITY OF THE OUT

The quantitative reliability requirements for the LCAC are estimated to be:

A. mean-time-between-failures (MTBF) - 260 hours

B. minimum acceptable (MTBF) - 130 hours

VI. MAINTAINABILITY OF THE OUT

The OUT shall be designed for ease of maintenance. The device shall have a design service life of at least ten years, and shall be designed to facilitate hardware and software modifications to reflect changes in the equipment installed on the operational LCAC vehicle. The quantitative maintainability design requirements for the OUT are estimated to be:

A. mean corrective maintenance downtime (M_{ct}) = 0.5 hour

B. maximum corrective maintenance downtime ($M_{max_{ct}}$) = 5.0 hour (90th percentile)

FUNCTIONAL DESCRIPTION

for

LCAC FULL MISSION TRAINER

I. PURPOSE OF DEVICE

A. The LCAC Full Mission Trainer (FMT) will be utilized to train LCAC operators/engineers/navigators in those unique skills and techniques involved in land/water craft operations. The FMT will be used to train operators/engineers/navigators in accomplishing 106 objectives as presented in Appendix A. Because design freeze on the LCAC cockpit has not been accomplished, this description is based on the JEFF(B) and will require update at the time of LCAC cockpit design freeze. It is intended to provide an order of magnitude of the detail and complexity of cockpit presentation.

B. The FMT will have the capability to train basic craft control, simulated amphibious assault operational mission and normal/emergency mode operations for LCAC craft systems under day/night and varying weather conditions.

C. It will also be utilized to provide refresher training for operators/engineers/navigators prior to being reassigned to an LCAC operational ACU and for instructor operators, engineers and navigators prior to duty in the LCAC training unit. In addition, it will be used to maintain the proficiency of operators, engineers, and navigators current in the LCAC.

II. TRAINING OBJECTIVES

A. Analysis disclosed that approximately 850 out of 946 behaviors can be accomplished in the FMT to the level of accomplishment required for LCAC operators/engineers/navigators. A behavior is defined as an activity required for the successful performance of a task/subtask. In addition, the FMT makes possible the measurement of an

operator's/engineer's/navigator's adaptability to craft operating tasks that may not be possible or practical in the operational craft because of resource and safety restrictions.

B. The training objectives for the FMT are as follows:

1. Reinforcement of trainee knowledge related to the characteristics, capabilities, and limitations of LCAC operating systems.

2. Reinforcement of all "in craft" pre-mission, underway and post mission procedures for both normal and emergency/abnormal conditions.

3. Provide the trainee with the skills and techniques required to perform all types of land/water mission and training operations.

4. Provide the trainee with the knowledge and skills required to perform operations and maintain craft control under varying visibility, sea/land, and/or wind conditions.

C. Specifically, the LCAC FMT will be utilized to train operators/engineers to partial or full mastery of performance of the following tasks/subtasks:

3.1	Perform Pre-mission Checklist Procedures
3.1.53	Direct Operating Crew Station Manning*
3.2	Start Craft
3.2.1	Perform Power-off Checklist Procedures*
3.2.2	Perform APU Start Checklist Procedures*
3.2.3	Perform Pre-start Checklist Procedures
3.2.4	Perform Main Engine(s) Start Checklist Procedures
3.3	Perform Pre-Underway Checklist Procedures

*denotes full proficiency

3.4	Perform Lift-off and Hover Checklist Procedures
4.1	Transit from Land to Water
4.1.1	Obtain Clearance as Required
4.1.2	Maneuver to Outbound Heading
4.1.3	Perform Land to Water Transition
4.1.3.1	Perform Ramp or Slipway to Smooth Water Transition
4.1.3.2	Perform Beach to Smooth Water Transition
4.1.3.3	Perform Beach to Surf Transition
4.2	Exit Wet/Dry Well (Self-Propelled)
4.2.1	Exit Wet Well (Self-Propelled)
4.2.2	Exit Dry Well (Self-Propelled)
4.3	Perform Station-Keeping
4.3.1	Perform Single Station-Keeping
4.3.2	Perform Formation Station-Keeping
4.4	Disengage from Ship
5.1	Perform Transition Over Hump
5.2	Change Course
5.2.1	Change Course Upwind
5.2.2	Change Course Downwind
5.2.3	Change Course Crosswind
5.3	Hold Craft on Track
5.4	Maintain Position in Formation Transit
5.5	Perform Mission-Dependent Tasks
5.6	Perform Underway Main Engine Water Wash
5.7	Perform Normal Stopping (Over Water)
5.8	Come Off-Cushion (Over Water)
5.9	Operate in Boating Mode

5.10	Come On-Cushion (Over Water)
6.1	Transit Water to Land
6.1.1	Perform Smooth Water Approach
6.1.2	Perform Surf Approach
6.2	Fly Up a Slope
6.3	Fly Across a Slope
6.4	Hold Craft on Track in Yaw Moment
6.5	Cross Obstacles
6.6	Perform Normal Stopping (Over Land)
6.7	Come Off-Cushion (Over Land)
6.7.1	Come Off-Cushion Level
6.7.2	Come Off-Cushion On Slope
7.1	Supervise Unload
7.2	Perform Lift-off and Hover Checklist Procedures
8.1	Transit From Land to Water
8.1.1	Obtain Clearance as Required
8.1.2	Maneuver Craft to Outbound Heading
8.1.3	Perform Land to Water Transition
8.1.3.1	Perform Beach to Smooth Water Transition
8.1.3.2	Perform Beach to Surf Transition
9.1	Perform Transition Over Hump
9.2	Change Course
9.2.1	Change Course Upwind
9.2.2	Change Course Downwind
9.2.3	Change Course Crosswind
9.3	Hold Craft on Track
9.4	Maintain Position in Formation Transit

9.5	Perform Mission-Department Tasks
9.6	Perform Underway Main Engine Water Wash
9.7	Perform Normal Stopping (Over Water)
9.8	Come Off-Cushion (Over Water)
9.9	Operate in Boating Mode
9.10	Come On-Cushion (Over Water)
10.1	Fly Up To Moving Ship
10.2	Moor To Ship
10.2.1	Moor To Ship Underway
10.2.2	Moor To Ship at Anchor (or Pier)
10.3	Refuel/Reload Craft
10.3.1	Perform Underway Refueling
10.3.2	Reload Craft (at Anchor)
10.4	Enter Well Deck (Self-Propelled)
10.5	Transit Water to Land
10.5.1	Perform Smooth Water Approach
10.5.2	Perform Surf Approach
11.1	Come Off-Cushion (Over Land)
11.2	Perform Craft Securing Checklist Procedures*
11.2.1	Perform Equipment Shutdown Procedures*
11.2.2	Perform Engine Shutdown Procedures*
11.2.3	Perform APU Shutdown Procedures*
11.3	Perform Refueling
11.4	Perform Mission Log Completion*
13.1	Perform Emergency Stopping
13.1.1	Perform Emergency Stopping Over Land

*denotes full proficiency

13.1.2 Perform Emergency Stopping Over Water

13.2 Perform Fire Emergency Procedures

13.2.1 Perform Engine Fire Emergency Procedures

13.2.2 Perform APU Fire Emergency Procedures

13.2.3 Perform Craft Fire Emergency Procedures

13.2.4 Perform Deck/Cargo Fire Emergency Procedures

13.3 Recognize and React to Propulsion Power Loss Emergencies

13.3.1 Perform Single Engine Failure Emergency Procedures

13.3.2 Perform Multiple Engine Failure Emergency Procedures

13.3.3 Perform Transmission Failure Emergency Procedures

13.3.4 Perform N2 Govern Failure Emergency Procedures

13.3.5 Perform Fueling Failure Emergency Procedures

13.3.6 Perform Fuel System (Main Engines) Emergency Procedures

13.3.7 Perform Fuel System (APU) Emergency Procedures

13.4 Recognize and React to Lift System Failure Emerg. Procedures

13.4.1 Perform Cushion Failure Emergency Procedures

13.4.2 Perform Keel/Lateral Stability Bags Loss Emerg. Procedures

13.4.3 Perform Loss of Lift Fan Emergency Procedures

13.5 Recognize and React to Degradation of Craft Control

13.5.1 Perform Control System Failure Emergency Procedures

13.5.2 Perform Propeller Failure Emergency Procedures

13.5.3 Perform Rudder Actuator Failure Emergency Procedures

13.5.4 Perform Bow Thruster Failure Emergency Procedures

13.5.5 Perform APU Failure Emergency Procedures

13.5.6 Perform Generator Failure Emergency Procedures

13.6 Perform Miscellaneous Emergency Procedures

13.6.1 Perform Flooding Emergency Procedures

13.6.2 Perform Man-Overboard Emergency Procedures

13.6.3 Perform Collision Emergency Procedures

13.6.6 Perform Plow-in Recovery

13.7 Perform Miscellaneous Abnormal Procedures

13.7.2 Perform Towing Operations

13.7.2.1 Perform Pre-Towing Checklist Procedures

13.7.2.2 Perform Towing Over Water

13.7.2.3 Perform Towing Over Land

13.7.3 Perform APU Protective Shutdown Procedures

13.7.4 Perform Main Engine Start Sequence Failure Procedures

14.1 Perform Buoy Operations

14.1.1 Perform Buoy Approach

14.1.2 Depart Buoy

14.1.3 Translate Side-to-Side Using Buoy as Reference

III. DEVICE DESCRIPTION

A. Overview

The FMT shall replicate the control station of the LCAC and its systems for the operator, engineer and navigator crew positions. It shall contain the capability to simulate all major tasks related to operator, engineer and navigator crew members for a given craft/mission combination. It shall have the capability of simulating environmental conditions necessary for mission performance including, but not limited to, motion, visual and dynamic vehicle characteristics.

B. Characteristics

1. The FMT shall contain one trainee station with three positions and one instructor station with two positions. Training proce-

dures shall include all skills and techniques required to perform the following training phases of operation:

a. Pre-launch
b. Depart
c. Transit Water (loaded)
d. Transit Beach
e. At Beach
f. Depart Beach
g. Transit Water (unloaded)
h. Reconfigure
i. Post-Mission
j. Emergency/Abnormal Conditions Procedures
k. Training Specific Tasks

2. Environmental variables to be simulated shall include, but not be limited to, fog, rain, sea states, wind, sand, and land/water surfaces.

3. The FMT shall simulate a tactical environment which will include the simulataneous distribution of hostile threats under varying weather, sea and land conditions. These threats shall include TBD enemy aircraft, TBD enemy and friendly surface ships and TBD shore installations. Target systems/sites to be simulated are TBD based on defined operational mission definition and planned areas of potential use.

C. Performance Parameters

1. The FMT will simulate TBD number of operational and craft training situations. Maximum range for training situations will be from host ship 24 miles offshore to landing site up to 1,000 yards inland. Areas of training criticality include the complex control of the craft in varying wind and land/sea conditions. More specifically, these complex craft control concepts include surf transit, plow-in conditions, and normal and emergency stopping. In addition, team coordinating (operator/engineer/navigator), operations involving reduced visibility (i.e., night, fog) as well as overall systems management are critical training areas.

2. The FMT will have the capability of simulating craft conditions to the following limitations:

   a. Maximum gross weight -- 355,000 pounds
   b. Maximum craft speed -- 70 knots over water, 50 knots over land
   c. Maximum wind speed -- 25 knots (headwind)
   d. Maximum sideslip (drift) angle -- 90°
   e. Maximum wave height -- 12 feet
   f. Maximum Sea State -- 5
   g. Water depth effects from 0-20 feet
   h. Ambient water temperature effects from -40°--110°F
   i. Vibration limits - not to exceed horizontal and vertical limits
   j. Support ship limits
      1. wind up to 25 knots
      2. speed 10 knots (dry well operations)
      3. ship motions-Trim $\pm 15°$, pitching $\pm 15°$, list $\pm 15°$, rolling $\pm 35°$
   k. Craft Center of Gravity (CG) at 355,000 pounds
      *1. Longitudinal - Hull station 479 to station 506
      *2. Lateral - 12.0 inches each side of craft longitudinal center line
      3. Vertical - Maximum 86.5 inches above waterline 0

      *based on hullborne damage stability criteria

   l. Craft controls
      1. Rudder - $\pm 30°$ travel at rate of 25°/sec.
      2. Propeller - +40°, -30° travel at rate of 20°/sec,
      3. Bow Thruster - forward mode 165° at rate of 50°/sec
         - reverse mode 165° at rate of 50°/sec.
      4. Vernier Pitch - $\pm 15°$ of center of yoke relative to propeller pitch setting
   m. Other craft - up to and including two other ACVs.

D. Performance Capabilities

Craft performance capabilities cannot be identified until LCAC design freeze, at which time a definitive task listing, media selection and syllabus will be developed. From the syllabus, preliminary simulator performance capabilities regarding degree of automation, student scoring, critique, debriefing and evaluation will be defined. Lesson specifications will then be developed from the syllabus. At the completion of the lesson specifications, specific simulator performance capabilities will be finalized.

E. Instructor Station

1. There shall be one instructor station with separate consoles for the navigator instructor and the operator/engineer instructor.

2. The instructor station shall be capable of complete trainer control to include the following:

   a. Implementing the Mission
   b. Inserting malfunctions/degrades
   c. Monitoring/Recording Trainee Actions
   d. Providing assistance to the instructor in his evaluation of trainee performance

3. There shall be an adequately sized CRT displays capable of displaying the following information to the instructor:

   a. Indicators, repeaters or other means of conveying information pertaining to cockpit switch positions and display readings.
   b. An effectiveness display for monitoring emergency procedures.

4. Trainer controls at the operators station shall be capable of performing the following:

   a. Automatic exercise setup/initiation to a set of given underway conditions.
   b. Performance parameter recording.
   c. Hard copy and/or digital plotter/printer printout of any set of selected underway parameters and display information.
   d. Automatic maneuver playback.
   e. A method for inserting gradual or abrupt degrades, malfunctions or emergencies for all craft systems.

f. A method for freeze and release of systems at any time.

g. An automatic collision alarm with override control.

h. Environmental controls to include:

(1) 360° wind control with velocity from 0-25 knots
(2) Sea States 1-5
(3) Daylight - night
(4) Vibration limits
(5) Craft gross weight
(6) Tactical environment

i. Communication control to include:

(1) Intercom between instructor and operator/engineer/navigator.
(2) Voice tape recorder synchronized with the mission evolution.
(3) Control of base/comm facilities.

F. Trainee Station

1. The trainee station shall be a replica of the LCAC control station cockpit for the operator, engineer and navigator crew positions. Device simulation shall provide for the duplication and interaction of all controls, instruments, communication and navigation systems and other equipment necessary to familiarize the trainees with those behaviors required to perform craft maneuvers, operate systems and respond to emergencies. Student activation of the controls and instrument displays shall duplicate the response of the LCAC.

2. Simulation of the entire LCAC control station cockpit for the operator, engineer and navigator positions shall be included in the trainee stations. Operator and engineer cockpit sections, their associated panels, displays, indicators and switches listed below are for the JEFF(B) craft and will be changed as

required upon design freeze of the LCAC cockpit. However, even though locations may change along with nomenclatures and types of displays, indicators and switches, an order of magnitude of the simulation problem can be gained. The navigator's station and specific tasks will be identified when operational mission scenario is defined.

a. Port side

(1) Ramp Control Panel

(a) STERN UP/OFF/DN switch
(b) STERN CLOSED light
(c) BOW CLOSED light
(d) BOW UP/OFF/DN switch

(2) Fuel Condition Panel

(a) MAIN VALVE OPEN/CLOSE switch
(b) OVERFILL light
(c) PRESSURE IN NOZZLE light
(d) PRESSURE IN MANIFOLD light
(e) FLOW INTO STRIPPING TANK-PORT light
(f) FLOW INTO STRIPPING TANK-STBD light
(g) PORT FILL light
(h) STBD FILL light
(i) TANK VALVES OPEN/CLOSE switches
(j) DRAIN VALVE - PORT MAIN switch
(k) Port Main DIRT light
(l) Port Main WATER IN FUEL light
(m) DRAIN VALVE - PORT APU switch
(n) Port APU DIRT light
(o) Port APU WATER IN FUEL light
(p) DRAIN VALVE - STBD MAIN switch
(q) Stbd Main DIRT light
(r) Stbd Main WATER IN FUEL light
(s) DRAIN VALVE - STBD APU switch
(t) Stbd APU DIRT light
(u) Stbd APU WATER IN FUEL light
(v) FUEL FILTER CONDN lights
(w) ENG OIL FILTER CONDN lights

(3) Console

(a) INST. button
(b) LTS. button
(c) HF switch
(d) VHF switch
(e) VHF-M switch
(f) UHF switch

(g) HF/VHF switch
(h) ADF switch
(i) VOL knob
(j) Rotary Selector knob
(k) AC VOLTS meter
(l) GEN LOAD meter
(n) GEN ON-OFF/RESET-TEST switch
(o) AUTO DROPOUT ORIDE/NORM switch
(p) GROUND FAULT meter
(q) EXT POWER switch
(r) DC VOLTS meter
(s) DC AMPS meter
(t) AUTO DROPOUT ORIDE/NORM switch
(u) MAIN TANK VALVE switches
(v) LOW PRESS Lights (port side)
(w) Port PRIMAR/STANDBY switch
(x) AUTO/MAN RESET switch
(y) Starboard PRIMARY/STANDBY switch
(z) LOW PRESS Lights (starboard side)
(aa) FUNCTION SELECTION rotary switch
(bb) SEQUENCE switch (port side)
(cc) VALVE OPERATE switch
(dd) SEQUENCE switch (starboard side)
(ee) INSTRUMENT rotary switch
(ff) NAV switch
(gg) ANCHOR switch
(hh) BCN switch
(ii) CARGO switch
(jj) ON/OFF/STOW switch
(kk) SEARCHLIGHT EXTEND/RETRACT switch
(ll) AUDIO ON/OFF switch

(4) Main Instrument Panel

(a) LUBRICATION OIL STATUS panel
(b) OIL TEMP DEGREES F. indicator
(c) OIL PRESS PSIG indicator
(d) RADIO MAGNETIC indicator
(e) SPED KNOTS indicator
(f) MASTER CAUTION light
(g) MASTER FIRE light
(h) FUEL QTY indicators
(i) FUEL MAN F, PRESS indicators
(j) APU ENGINE PERCENT RPM indicators
(k) APU EGT DEGREES F indicators
(l) NO. 1 APU CRANK/OFF switch
(m) NO. 1 APU START/STOP/RUN switch
(n) NO. 1 APU T/R PWR - BAT PWR switch
(o) NO. 2 APU CRANK/OFF switch
(p) NO. 2 APU START/STOP/RUN switch
(q) NO. 2 APU T/R PWR - BAT PWR switch
(r) ENGINE HEALTH MONITOR display units

b. Center Console

(a) Top Section

(a) BT switch
(b) R switch
(c) PROPS PORT switch
(d) PROPS STBD switch
(e) VERNIER PITCH switch
(f) OPER/STOW MODE switch
(g) FWD/REV MODE switch
(h) PORT gage
(i) STBD gage
(j) ENGINE MASTER switch
(k) Annunciator Panel
(l) DE-ICE switch (configured)
(m) WASH switch (configured)
(n) WIPER switch (configured)
(o) Wiper Control rotary switch (configured)
(p) DECK PWR OVED switch
(q) ZONE A TEST switch
(r) ZONE B TEST switch
(s) ZONE C TEST switch
(t) COUPLING R-BT switch
(u) COUPLING BT-R switch
(v) FRICTION wheel
(w) N_2 PORT ENGS lever
(x) N_2 STBD ENGS lever
(y) PORT PROP lever
(z) STBD PROP lever
(aa) FRICTION wheel

(2) Lower Section

(a) Fire Pull Handles
(b) Engine 2 PURGE/RESET switch
(c) Engine 2 START/STOP switch
(d) Engine 2 N_2 BRAKE switch
(e) Engine 4 PURGE/RESET switch
(f) Engine 4 START/STOP switch
(g) Engine 4 N_2 BRAKE switch
(h) Engine 3 PURGE/RESET switch
(i) Engine 3 START/STOP switch
(j) Engine 3 N_2 BRAKE switch
(k) Engine 1 PURGE/RESET switch
(l) Engine 1 START/STOP switch
(m) Engine 1 N_2 BRAKE switch
(n) FRICTION wheel
(o) ENG 2 throttle
(p) ENG 4 throttle
(q) ENG 3 throttle
(r) ENG 1 throttle
(s) FRICTION wheel
(t) ARM switch

(u) TEST RELAY 3 switch
(v) TEST RELAY 2 switch
(w) TEST RELAY 1 switch
(x) ALIGN TEST B button
(y) ALIGN TEST A button
(z) RESET button
(aa) B/T 2 light
(bb) B/T 1 light
(cc) RUDDER 2 and 4 lights
(dd) RUDDER 1 and 3 lights
(ee) PROP 2 light
(ff) PROP 1 light

c. Starboard Side

(1) Console

(a) LTS buttons
(b) HF SWITCH
(c) VHF switch
(d) VHF-M switch
(e) UHF switch
(f) HF/VHF switch
(g) ADF switch
(h) VOL knob
(i) Rotary Selector knob
(j) Gyro Synchronization indicator
(k) SLAVED/FREE SWITCH
(l) PUSH TO SET knob
(m) Thumbwheel Selector
(n) SELECTOR rotary switch
(o) PWR HI/LO switch
(p) SQUELCH knob
(q) MEGACYCLES knobs
(r) RCVR TEST button
(s) VHF-FM selector knob
(t) AUDIO knob
(u) 48.75.95 MHZ/30.47.95 MHZ FREQ BAND switch
(v) POWER OUTPUT HIGH/LOW switch
(w) THERMOSTAT knob (configured)
(x) THERMOSTAT OVERRIDE switch (configured)
(y) CONTROL BREAKER switch (configured)
(z) MAIN BREAKER switch (configured)
(aa) MASTER switch (configured)
(bb) SELECTOR switch (configured)
(cc) INSTR rotary transformer switch
(dd) CONSOLE 28V rotary switch
(ee) DOME RED ON/OFF switch
(ff) DOME WHITE ON/OFF switch
(gg) CONSOLE 115V rotary switch
(hh) RED ON/OFF button
(ii) WHITE ON/OFF button

(2) Main Instrument Panel

(a) AFT FUEL pull handle
(b) FWD FUEL pull handle
(c) LUBE OIL VALVES - PORT PROP OPEN/CLOSE switch
(d) LUBE OIL VALVES - PORT FWD OPEN/CLOSE switch
(e) LUBE OIL VALVES - PORT AFT OPEN/CLOSE switch
(f) LUBE OIL VALVES - STBD PROP OPEN/CLOSE switch
(g) LUBE OIL VALVES - STBD FWD OPEN/CLOSE switch
(h) LUBE OIL VALVES - STBD AFT OPEN/CLOSE switch
(i) STBD CLUTCH ENGAGE/DISENGAGE switch
(j) PROP PITCH indicator
(k) PORT CLUTCH ENGAGE/DISENGAGE switch
(l) WIND SPEED KNOTS indicator
(m) EGT, DEGREES, FX100 indicators
(n) N_2, PWR, % RPM indicators
(o) N_1 GG, % RPM indicators
(p) MASTER CAUTION light
(q) MASTER FIRE light
(r) RADIO MAGNETIC INDICATOR gage
(s) ELAPSED TIME clock
(t) SEA COND ROUGH/CALM switch
(u) PITCH indicator
(v) ROLL indicator
(w) RATE OF TURN DEG/SEC indicator
(x) Control Wheel
(y) MIC-INTERCOM switch
(z) TRIM REL switch
(aa) SPEED RADAR display

3. The accuracy of read-out information in response to operator inputs shall be in accordance with the conditions and standards requirements of each task criterion objective.

4. Each task/subtask was analyzed by subject matter experts in terms of internal and external visual, audio and motion conditions present at the time of performance and whether the condition is a primary or secondary cue. Special simulation effects disclosed in the analysis were recorded on individual cue sheets for each task/subtask. The trainee station of the FMT shall simulate the following device special simulation effects as represented on the cue sheets:

a. Sound

(1) Engine
(2) APU
(3) Transmission
(4) Propeller pitch
(5) Bow thruster
(6) Hull (on-cushion)
(7) Hull (off-cushion)
(8) Configuration changes
(9) Aural warning tones

b. Lighting

(1) Daylight
(2) Night

c. Motion

(1) The FMT will incorporate an external motion cueing system. Analysis disclosed that 46% of the total task/subtask listing require motion as a primary cue with the emphasis on roll, pitch and yaw. Combinations of these three degrees, as well as individual and combined requirements for heave, surge and sway, are also present and will enhance other task performance. Thus, a motion system with six degrees of freedom is recommended.

(2) The FMT will incorporate a control loading system to provide control yoke and rudder pedal feel.

(3) The fidelity of motion system combinations shall be adequate to compliment visual cues.

d. Visual System

(1) The visual system shall utilize Computer Generated Imagery in providing specific scenes necessary for achieving the following training capabilities:

(a) Over Terrain - Terrain should include hills or slopes, ditches, obstacles such as houses, walls, step changes in elevation, and trees. Beyond these features a flat terrain extending to the horizon is desirable. These terrain features may be all located within an area 1 mile by 1 mile.

(b) Beach - The beach scene is composed of surf, a smooth sloping beach, trees or other TBD objects at the upper edge of the beach, and a flat terrain beyond the beach. The line of the crests of the breakers is parallel to the beach; the crests will have variable spacing.. In its simplest form the surf may be stylized to be only a flat, textured, moving surface. This scene will be viewed both in going from the ocean to land and returning.

(c) Ocean with Obstacles - The ocean would consist of long crested waves extending to infinity in all directions. The crests would be uniformly spaced and move at a constant velocity. In its simplest form the ocean may also be stylized to be only a flat textured surface that moves with respect to the stationary objects. The interaction of the waves with the ships' hulls represents an aspect of the display problem of varying difficulty, depending upon the method used in the visual display. This is covered in the discussion of the visual display options in Appendix B. Also included in the ocean scene would be several stationary box-like obstacles. These would represent objects the LCAC may have to avoid.

(d) Ocean with a Supply Ship - The supply ship may move at low velocity over the ocean surfacce at

any heading relative to the LCAC and may be subjected to heave, pitch and roll motions; these motions will be apparent with respect to the ocean surface.

(e) Ocean with an LSD - Included as a part of the LSD should be an entrance well in the transom for the LCAC. As with the supply ship it is free in azimuth, it can move with some velocity over the ocean surface and it may experience heave, pitch and roll motions which change the ship's attitude noticeably with respect to the ocean surface. Of particular criticality is the well deck detail during closure/separation in well deck entry/exit.

(f) The Visual Simulation of Fog - The option should be provided for making the visual scene contrast a function of the range along the line of sight. Ideally, this would be accomplished by summing an intensity signal proportional to range with the scene information.

(2) The visual scenes shall respond in real time to the craft conditions, controls and mission characteristics of the LCAC. The level of scene detail and resolution must be sufficient to provide the appropriate realism and cues during actual craft mission.

(3) Maximum field of view range for the FMT based on task assessment shall be 75° horizontal port side, 90° horizontal starboard side and $\pm 20°$ vertical. Cost estimation for these specifications may suggest task assessment trade-off resulting in a reduced FOV range.

5. Specific failures and malfunctions to be simulated shall include the following emergency and abnormal operating procedures:

a. Emergency stopping over land/water
b. Engine fire emergency
c. APU fire emergency
d. Craft fire emergency
e. Deck/cargo fire emergency
f. Single engine failure
g. Multiple engine failure
h. Transmission failure
i. N_2 Govern failure
j. Fueling failure
k. Fuel system (main engines) failure
l. Fuel system (APU) failure
m. Cushion failure
n. Keel/lateral stability bags loss
o. Loss of lift fan
p. Control system failure
g. Propeller failure
h. Rudder actuator failure
s. Bow Thruster failure
t. APU failure
u. Generator failure
v. Flooding emergency
w. Man-overboard emergency
x. Collision emergency
y. Plow-in recovery emergency
z. Towing operations over land/water
aa. APU protective shutdown failure
bb. Main engine start sequence failure

IV. AVAILABILITY AND UTILIZATION OF DEVICE

A. Utilization of the FMT in regards to hours/day, days/week, and weeks/year as required for training to meet the curriculum will be defined upon completion of the Underway syllabus. However, maximum utilization of the FMT is estimated as approaching 16 hours/day, 240 days/year at the time of full pipeline input by 1990.

B. The FMT instructor to student ratio shall be as follows:

1. one operator and one engineer per operator instructor

2. one navigator per navigator instructor

C. The FMT shall have an operational service life of not less than 10 years or 48,000 hours under any of the operating and non-operating environments specified herein before major modification is necessary. Operational service life is defined as the total operating time between the start of the operation and wear-out; where wear-out is defined as the point when overhaul or repair cost exceeds one- half of the replacement cost of the FMT.

D. The control yoke and rudder pedals shall require special design attention because they are more heavily used than other instruments and controls.

E. Types of exercises and time limits required as well as high/low periods of device utilization will be specifically defined during development of the long-term LCAC syllabus.

F. The FMT will be the first ACV training device of any type; therefore, no system similar to the FMT is currently utilized.

V. RELIABILITY OF THE FMT

The quantitative reliability requirements for the LCAC are estimated to be:

A. mean-time-between-failures (MTBF) - 260 hours

B. minimum acceptable (MTBF) - 130 hours

VI. MAINTAINABILITY OF THE FMT

The FMT shall be designed for ease of maintenance. The device shall have a design service life of at least ten years, and shall be designed to facilitate hardware and software modifications to reflect changes in the equipment installed on the operational LCAC vehicle. The

quantitative maintainability design requirements for the FMT are estimated to be:

A. mean corrective maintenance downtime (M_{ct}) = 0.5 hour

B. maximum corrective maintenance downtime ($M_{max_{ct}}$) = 5.0 hour (90th percentile)

APPENDIX D

CONCEPTUAL DRAWINGS OF AIR CUSHION VEHICLE TRAINING DEVICES

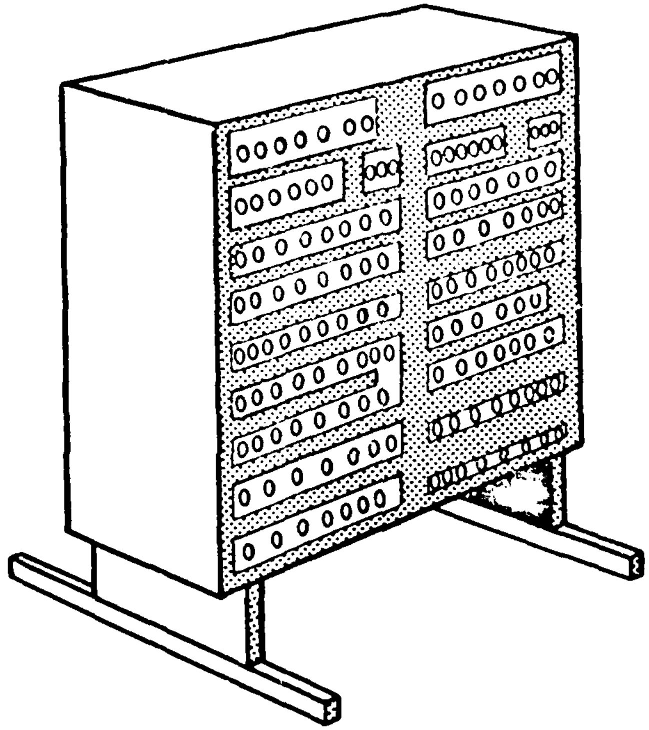

FIGURE D-1

Simple Part-task Trainer A (PTT1-A)
(Circuit Breaker Panel)

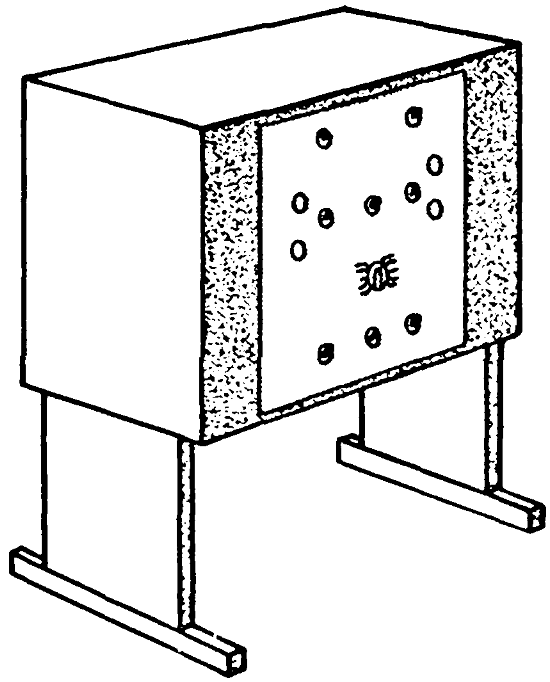

FIGURE D-2

Simple Part-task Trainer B (PTT1-B)
(Fuel Management Panel)

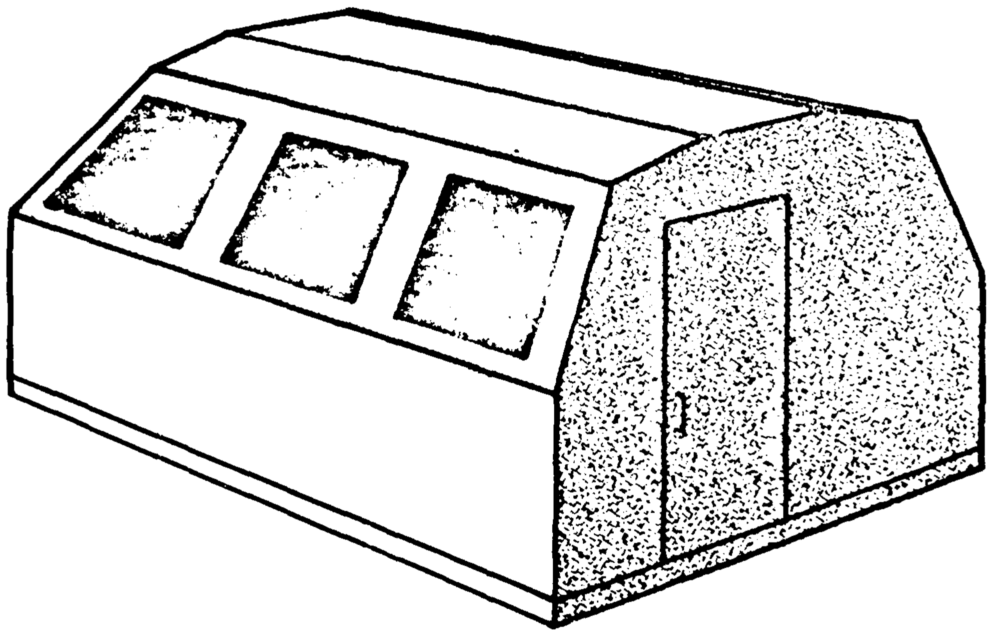

FIGURE D-3

Cockpit Familiarization Trainer (CFT)

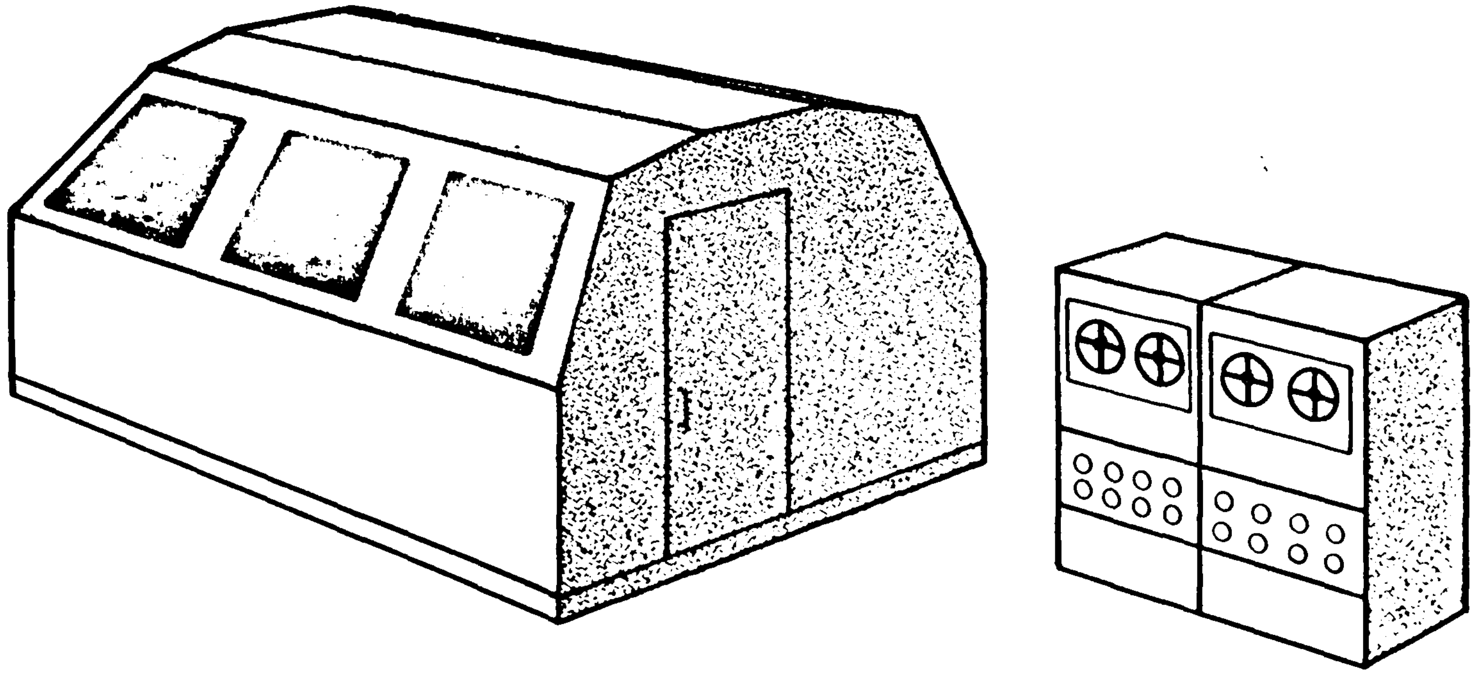

FIGURE D-4

Cockpit Procedures Trainer (CPT)

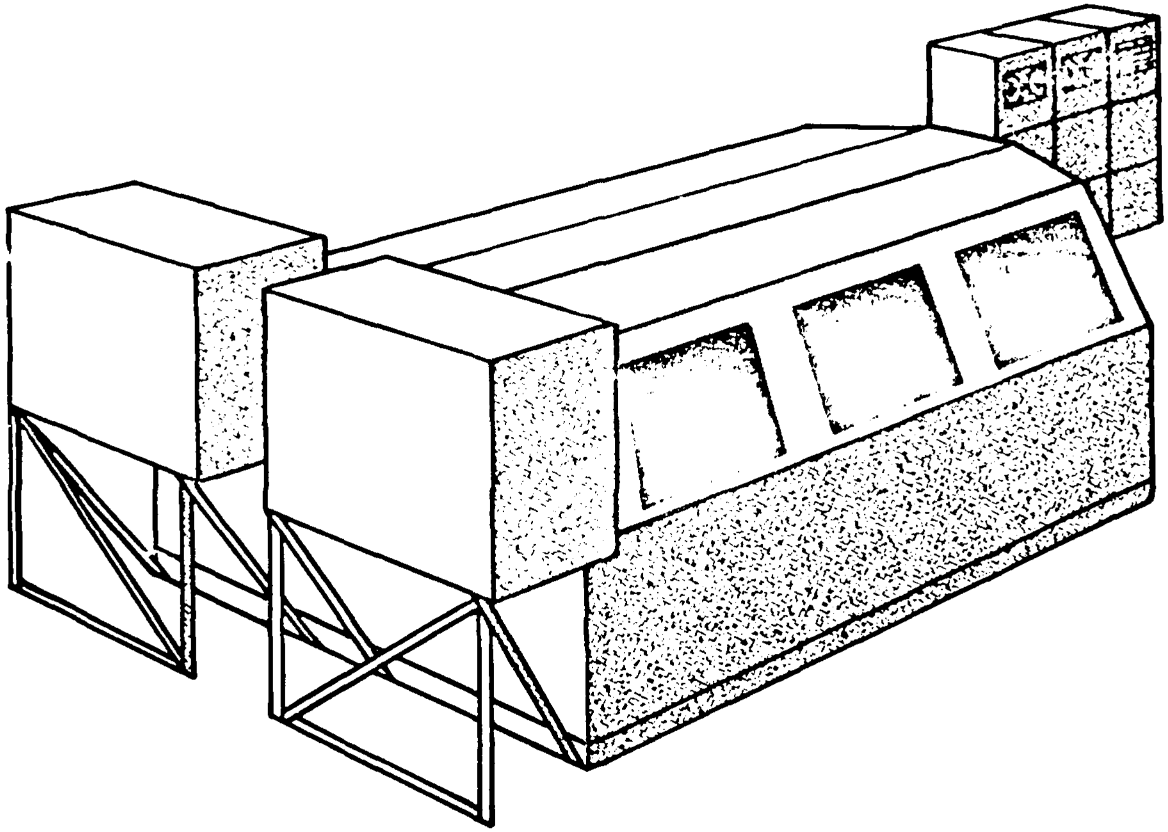

FIGURE D-5

Complex Part-task Trainer (PTT2)

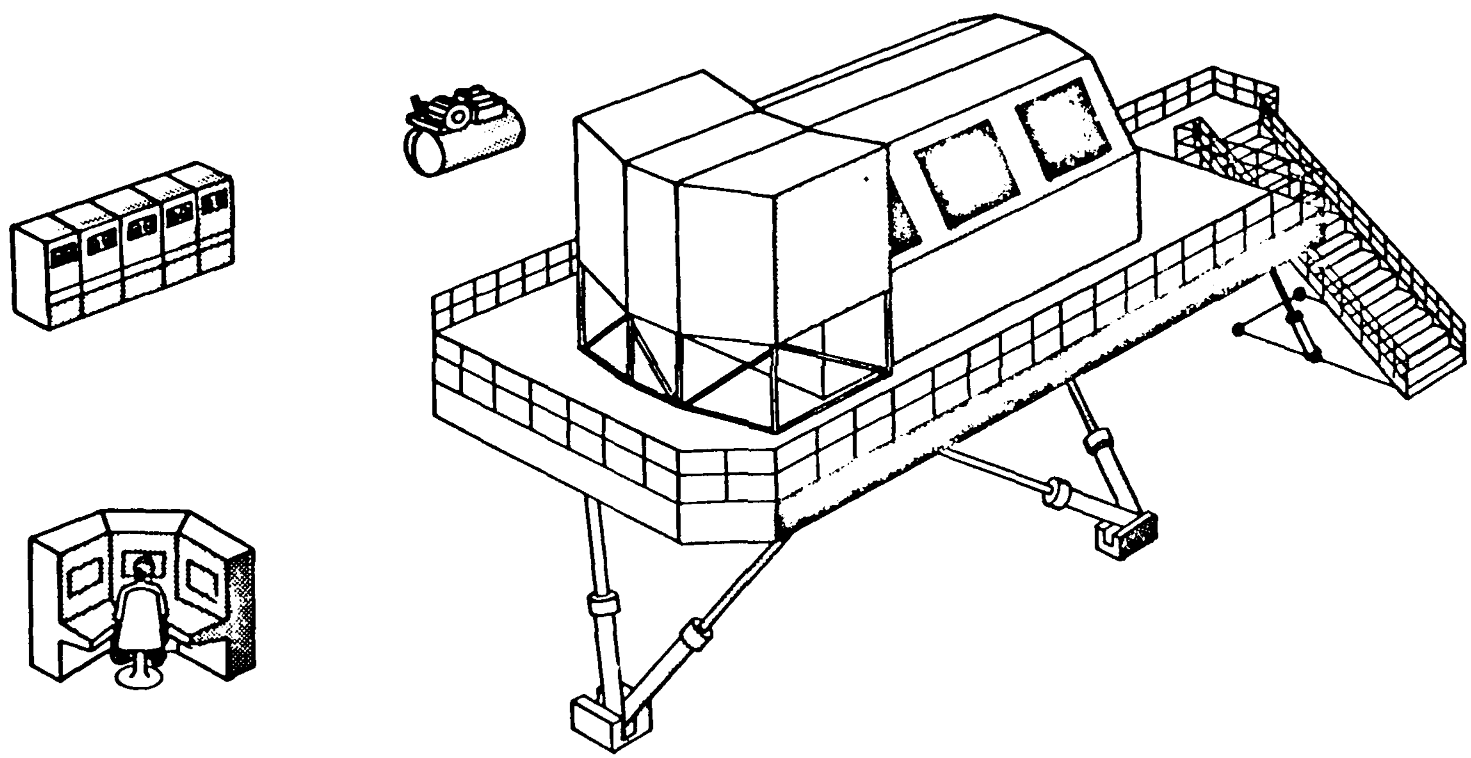

FIGURE D-6

Operational Underway Trainer (OUT)

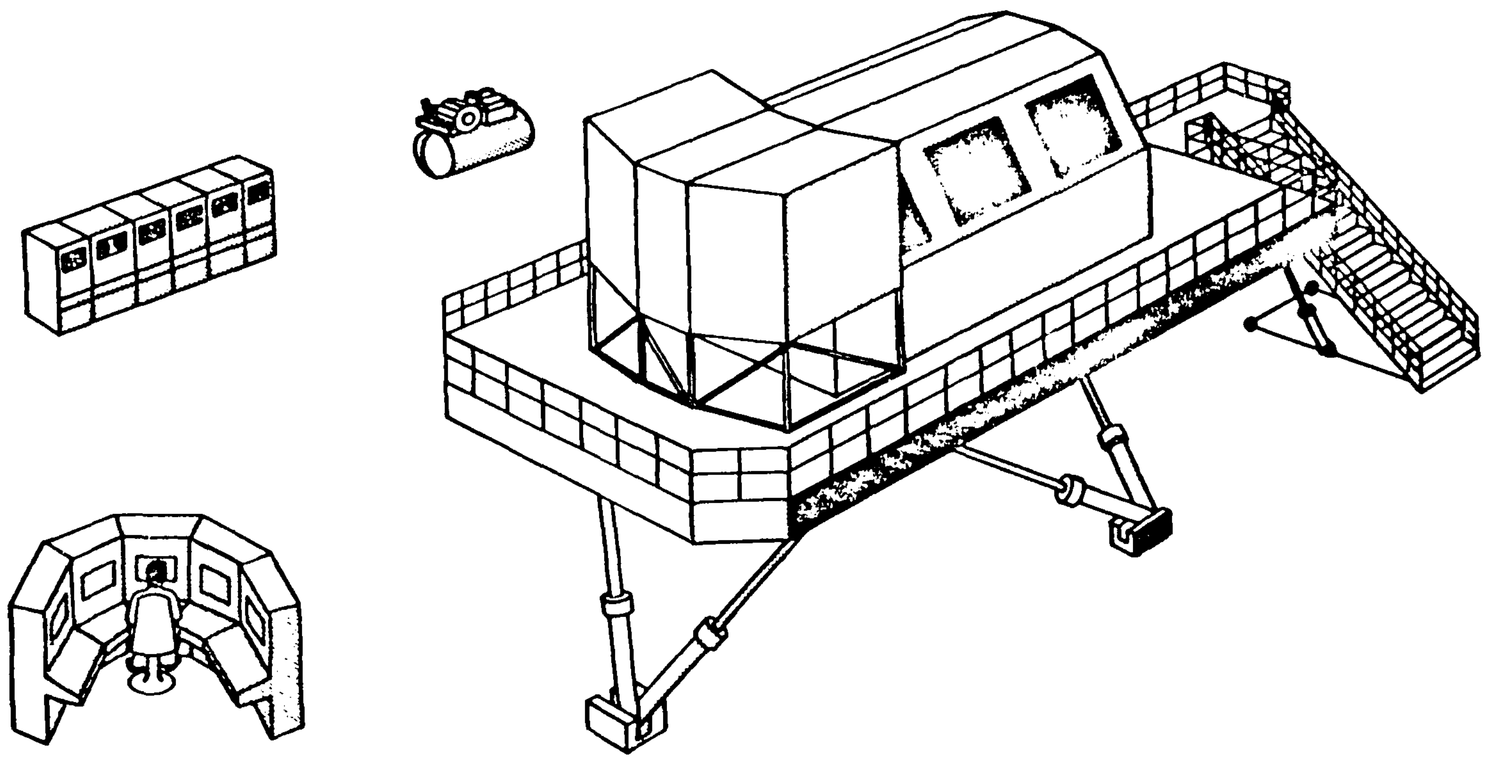

FIGURE D-7

Full Mission Trainer (FMT)

APPENDIX E

ACVOTS TRAINING DEVICE COST ESTIMATES

APPENDIX E
ACVOTS TRAINING DEVICE COST ESTIMATES

Estimates of procurement and operating costs for each candidate device and the LCAC craft were developed from procurement estimates and utilization calculations as described in Section III of Volume I. These are presented in Figure E-1. All cost estimates are in 1982 dollars and do not include inflation or discounting. The device operating costs include amortized cost, electricity at $.075/kwh and maintenance technician time at $20 per hour where applicable, as well as instructor time at $30 per hour. Craft operating costs include amortized cost, spare parts, dedicated billets, overhaul at four years, organizational equipment and fuel and periodic oil lubrication costs. These costs are based on 600 hours/year availability and are based on projected estimates for the LCAC[7].

The candidate mixes constructed in Section III were subjected to analysis aimed at obtaining relative training costs for both 12 trainees per year (1st year of system implementation) and 54 trainees per year (early 1990s). The rationale for testing device mixes with 54 trainees per year involves the following conditions:

- 108 craft in fleet,
- complete crew replacement every second year, and,
- single training device site.

The first mixes addressed were the single device/craft mixes of which there were four (A, B, C and D). Training cost estimates were calculated based on data in Appendix E, and using those estimates, total mix cost-to-train figures were obtained. The next level mixes (E, F, G and H) involved the combination of a low level procedures-type trainer (CFT or CPT) and a high level operational trainer (OUT or FMT). Based on the assumptions presented in Section III of Volume I, maximum utilization of the lower level trainer left a remainder of utilization on the higher level trainer with no greater

[7] Air Cushion Landing Craft Cost Models, SRI Report, NWRC, TN-80, July 1978.

Device	Estimated Acquisition Cost	Utility Costs (@ $.075/kwh)	Maximum Utilization/Year* 12 Trainees		Composite Cost/Hour**(12)	Composite Cost/Hour**(54)
			12 Trainees	54 Trainees		
CFT	$ 150,000	$0.50/hr.	234 hrs.	1,054 hrs.	$ 85/hr.	$ 50/hr.
PTT1-A	15,000	$0.00/hr.	1 hr.	4.5 hrs.	1,030/hr.	250/hr.
PTT1-B	20,000	$0.00/hr.	48 hrs.	217 hrs.	60/hr.	35/hr.
CPT	1,750,000	$1.50/hr.	324 hrs.	1,460 hrs.	402/hr.	120/hr.
PTT2	8,750,000	$2.00/hr.	253 hrs.	1,140 hrs.	2,350/hr.	550/hr.
OUT	19,000,000	$4.50/hr.	683 hrs.	2,074 hrs.	1,904/hr.	655/hr.
FMT	21,000,000	$4.50/hr.	691 hrs.	3,108 hrs.	2,070/hr.	495/hr.
LCAC	11,000,000	N/A	881 hrs.	3,964 hrs.	6,225/hr.***	6,225/hr.***

*Based on individual device capability for operator task behaviors.

**Includes electricity (where applicable), burdened instructor ($30/hr.) and maintenance technician ($20/hr.) time (where applicable) at a 1:2 ratio with operating time.

***Cost/Hr. includes $5,000/hr. operating cost which includes fuel, spares, maintenance, billets, etc.

Figure E-1. ACVOTS Training Device/Operational Craft Cost Estimates

impact on required craft underway time than the high level operational trainers alone. Training cost estimates were then calculated as before.

The next level mixes (I and J) involved a low level procedures trainer (CFT or CPT) and the complex part-task trainer (PTT2). Here, maximum utilization of the lower level trainer was assumed. The time allocation for the PTT2 was obtained via a task-by-task behavior allocation as in the initial task annotation. All behaviors that could be performed in the lower level trainer were subtracted from those which could be performed in the PTT2. A new utility rating for the PTT2 for each task was then calculated in each of the two mixes. From this calculation a new total syllabus time allocation per student was determined. Those two mixes generated a reduction in craft time more than with each device individually.

Similarly, in mixes K and L, all device-capable training was loaded into the PTT2 based on its original rating, and in a task-by-task behavior reallocation, new utility ratings for the OUT and FMT were determined. Total mix training costs were calculated as before. These two mixes generated a reduction in craft time more than the complex trainers alone.

The final group of candidate training device mixes (M, N, O and P) involved the lower level procedures trainers (CFT or CPT), the PTT2 and the higher level operational trainers (OUT or FMT). The analysis conducted for mixes I and J were applied behavior-by-behavior against the two operational trainers' capabilities in the annotated task listing, and new utilization ratings were determined for these two devices for each task within each of the four mixes. Thus, new total syllabi device allocation times per student were determined and training costs for each mix calculated. Device mix annual utilization and training cost estimates for both 12 and 54 trainees per year are presented in Figure E-2.

Finally, the two panel mock-up part-task trainers were added singly and in combination to Mix N to test the training and cost impact of their inclusion. These mock-ups reduce the utilization of the CFT since, as previously discussed, these panels' use in the higher level device (FMT in this case) was already moved to the CFT in the earlier analysis of Mix N. Results of this analysis are presented in Figure E-3. Due to the minor

Mix	Hours/Year		Cost/Year	
	12 trainees	54 trainees	12 trainees	54 trainees
P.				
CPT	324	1,460	$ 130K	$ 177K
PTT2	204	917	592K	622K
FMT	274	1,234	1,412K	1,455K
LCAC	79	353	491K	2,197K
Totals	881	3,964	$2,624K	$4,451K
O.				
CPT	324	1,460	$ 130K	$ 177K
PTT2	204	917	592K	622K
OUT	266	1,197	1,279K	1,320K
LCAC	87	390	542K	2,428K
Totals	881	3,964	$2,543K	$4,547K
N.				
CFT	234	1,054	$ 20K	$ 53K
PTT2	209	941	592K	623K
FMT	343	1,544	1,415K	1,469K
LCAC	95	425	591K	2,646K
Totals	881	3,964	$2,618K	$4,791K
M.				
CFT	234	1,054	$ 20K	$ 53K
PTT2	209	941	592K	623K
OUT	334	1,501	1,282K	1,333K
LCAC	104	468	647K	2,913K
Totals	881	3,964	$2,541K	$4,922K
L.				
PTT2	253	1,140	$ 594K	$ 631K
FMT	469	2,112	1,421K	1,494K
LCAC	159	712	990K	4,432K
Totals	881	3,964	$3,005K	$6,557K
K.				
PTT2	253	1,140	$ 594K	$ 631K
OUT	461	2,074	1,287K	1,359K
LCAC	167	750	1,040K	4,669K
Totals	881	3,964	$2,921K	$6,659K

Figure E-2. ACVOTS Training Device Mix Cost Estimates
(Rank by lowest to highest cost)

Mix	Hours/Year		Cost/Year	
	12 trainees	54 trainees	12 trainees	54 trainees
D.				
FMT	691	3,108	$1,431K	$1,538K
LCAC	190	856	1,183K	5,329K
Totals	881	3,964	$2,614K	$6,867K
F.				
CFT	234	1,054	$ 20K	$ 53K
FMT	457	2,054	1,420K	1,491K
LCAC	190	856	1,183K	5,329K
Totals	881	3,964	$2,623K	$6,873K
C.				
OUT	683	3,074	$1,297K	$1,403K
LCAC	198	890	1,233K	5,540K
Totals	881	3,964	$2,530K	$6,943K
E.				
CFT	234	1,054	$ 20K	$ 53K
OUT	449	2,020	1,287K	1,357K
LCAC	198	890	1,233K	5,540K
Totals	881	3,964	$2,540K	$6,950K
H.				
CPT	324	1,460	$ 130K	$ 177K
FMT	367	1,648	1,416K	1,473K
LCAC	190	856	1,183K	5,329K
Totals	881	3,964	$2,729K	$6,979K
G.				
CPT	324	1,460	$ 130K	$ 177K
OUT	359	1,614	1,283K	1,338K
LCAC	198	890	1,233K	5,540K
Totals	881	3,964	$2,646K	$7,055K
J.				
CPT	324	1,460	$ 130K	$ 177K
PTT2	204	917	592K	622K
LCAC	353	1,587	2,197K	9,879K
Totals	881	3,964	$2,919K	$10,678K

Figure E-2. ACVOTS Training Device Mix Cost Estimates (cont'd.)
(Ranked by lowest to highest cost)

Mix	Hours/Year		Cost/Year	
	12 trainees	54 trainees	12 trainees	54 trainees
I.				
CFT	234	1,054	$ 20K	$ 53K
PTT2	209	941	592K	623K
LCAC	438	1,969	2,727K	12,257K
Totals	881	3,964	$3,339K	$12,933K
B.				
CPT	324	1,460	$ 130K	$ 177K
LCAC	557	2,504	3,467K	15,587K
Totals	881	3,964	$3,597K	$15,764K
A.				
CFT	234	1,054	$ 20K	$ 53K
LCAC	647	2910	4,028K	18,115K
Totals	881	3,964	$4,048K	18,168K

Figure E-2. ACVOTS Training Device Mix Cost Estimates (cont'd.)
(Ranked by lowest to highest cost)

PTT1-A	1	4.5	$ 1K	$ 1K
CFT	233	1049.5	20K	53K
PTT2	209	941	592K	623K
FMT	343	1544	1,415K	1,469K
LCAC	95	425	591K	2,646K
Totals	881	3964	$2,619K	$4,792K
PTT1-B	48	217	$ 3K	$ 8K
CFT	186	837	18K	44K
PTT2	209	941	592K	623K
FMT	343	1544	1,415K	1,469K
LCAC	95	425	591K	2,646K
Totals	881	3964	$2,619K	$4,790K
PTT1-A	1	4.5	$ 1K	$ 1K
PTT1-B	48	217	3K	8K
CFT	185	832.5	18K	44K
PTT2	209	941	592K	623K
FMT	343	1544	1,415K	1,469K
LCAC	95	425	591K	2,646K
Totals	881	3964	$2,620K	$4,791K

Figure E-3. Training Cost Estimates for Addition of PTT1-A and/or PTT1-B to Mix N.

training impact and relatively high utilization cost of these mock-ups with resultant higher net mix training cost, the analysis investigators eliminated them from further consideration.

While the craft utilization times in mixes M, N, O, and P may appear low, they are close to what may be accomplished. The analysis investigators believe an actual craft utilization time of 12-15 hours per student is realistically achievable. Furthermore, it is within the realm of projected maximum learning transfer typical of a totally integrated training approach.